Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

AUGUST, 1913.

THE STREAMLESS DOWNS AND THEIR DRY VALLEYS.

By G. W. BULMAN, M.A., B.Sc.

ONE of the most striking things on the Chalk Downs of the south of England is the absence of streams.

> "We have no waters to delight
> Our broad and brookless vales,
> Only the dew-pond on the height
> Unfed that never fails."

And the reason is obvious. The substratum of chalk is so pervious that the rain sinks into the rock at once, and none can run off to form streams. Another feature of the Downs are the numerous dry valleys, which look as if they had been carved by water. We may call the coëxistence of the two features the puzzle of the physical geography of the Downs. If there are no waters to cut them out, to what do we owe "Our broad and brookless vales"?

In the "Memoirs of the Geological Survey" ("The Geology of the Country round Eastbourne") we find the following suggestion by Mr. Clement Reid:—

"Such a feature in the pervious chalk cannot be accounted for by any change in the amount of rainfall; it points to other conditions which have now passed away. It is in all probability a relic of the Glacial Epoch, which in these southern districts did not lead to an accumulation of ice, but caused the rocks to freeze to a great depth, thus rendering them impervious to any rain that might fall in the summer. During that period the chalk would be cut into valleys in the same way as any impervious rock, instead of immediately absorbing the heaviest rain, as it does at the present day."

Any suggestions coming from so distinguished a geologist as Mr. Clement Reid must be received with due respect, but there seems to be more than one fatal objection to this explanation. It assumes, in the first place, that the porous chalk became saturated with water to the surface, and was then frozen hard. But if the rain sank into the chalk as it does to-day this could never happen. Even after the wettest season the line of saturation never rises to near the surface.

In the second place, is there any ground for the belief that during glaciation the ground would be frozen to great depths? As a matter of fact, in glaciated regions to-day ice and snow seem to keep the earth warm. For there always seems to be water under the glacier and ice-sheet. Mr. Reid, however, seems to suggest that the southern parts of the country were not covered with ice or snow during glaciation. But we cannot hypothesise a sufficiently heavy snowfall in the north to produce glaciation, and none or very little in the south. Nor can we suppose there was a summer rainfall sufficient to cut the valleys without admitting a corresponding snowfall in the winter. Would not, then, the Downs be covered with snow and the ground thus kept from freezing? And even if summer began with a frozen ground, would it not begin to melt simultaneously with the first rain? We further venture to think that if these dry valleys in the chalk had been carved during the glacial period they would now show signs of filling up. For there must be some movement of material into them from the higher ground at the sides, and there has been time for some to be almost obliterated. But instead of thus growing less they seem rather to be still in course of formation.

We venture, therefore, to suggest as a tentative hypothesis that our dry chalk valleys are the lines of underground waters comparable to the Oueds of the African deserts; not as to origin, but in the fact

XUM

that they are underground rivers. The Oueds of the Sahara are buried rivers, but to-day no rivers are to be seen, only more or less fertile valleys in the desert marking their courses. The rivers have been buried by the drifting sand, but their waters still pass along the old channels. In a different way we suggest that the waters of the Downs have become underground streams, which have made their own now streamless vales. Suppose the line of such a valley lies among the main dip, and that rolls in the chalk cause minor dips on both sides towards this. The rain sinking into the chalk will descend till it reaches an impervious substratum. Then it will soak on both sides towards the central lines of the valley. Reaching this it will, along with what reaches it directly from the surface, flow or soak along the main dip. All the time it is dissolving and carrying away the rock, and the surface gradually sinks in, as it does in the formation of swallow holes. Thus we suggest that the dry valleys of the chalk are due to subsidence caused by underground waters directed by the slopes of the strata.

The action of the underground water would be assisted in a small degree by that of the surface. For when a channel was once formed the rain water would tend to collect in the hollow in the form of soaked soil or subsoil. Here, then, the solvent action would be greater, and the making of the valley hastened. The whole is a tentative hypothesis only, but one that seems worthy of careful consideration. And, apart from any inherent probabilities in their respective suppositions, it appears to possess this advantage over the glacial hypothesis, that it views the valleys as still in the making. Mr. Reid's explanation, on the other hand, looks upon them as completed in the Glacial Epoch. And we think that there is evidence that the denuding forces are still at work, for otherwise would they not show signs of filling up? There must be a certain amount of slipping and sliding and washing of matter into the valleys from the sloping sides which would tend to obliterate them. But they do not, as we have said, appear to be growing less.

It is possible, however, that some of these valleys date back for their initiation to the time when the chalk was covered by Tertiary deposits, sandstones, clays, limestones, and so on. In these strata streams might cut out valleys in the ordinary way. When these rivers had got down to the chalk, their beds would contain sufficient clay, and so on, to prevent them altogether being absorbed. The chalk itself might have become impregnated with clay to a certain depth, and so have become impervious. This might last long enough for the stream to cut down the chalk to a certain extent. Finally, however, all clay and impervious chalk would be swept away, and the rain sink directly into the ground as it does to-day. But we need not suppose that the river which cut the valley has actually gone. It may, so to speak, have sunk into the ground, and be still carrying on its work of excavation. Obviously, at any rate, the water which normally runs off as streams and rivers is in some fashion working its way through the rocks below.

We may carry the idea of underground streams and rivers a little further. The invisible waters of the downs flow finally into a great subterranean lake which lies in the rocks beneath the lower valley of the Thames. There they are joined by a similar set of streams from the chalk hills north of London. For the chalk of the south of England dips beneath the strata of the London basin, and rises again to the north. The Tertiary rocks of the London basin, in fact, lie in a syncline or trough of the chalk, and in this the water collects. So a part of the rain falling on the Downs finds its devious way to the great subterranean reservoir over which is built the Metropolis. When an artesian well is sunk through the Tertiary beds and a part of the chalk an abundant water supply gushes out. The waters which should "delight our broad and brookless vales" go unseen to supply the deeper wells of the city of London.

ADDITIONS TO THE ZOÖLOGICAL SOCIETY'S MENAGERIE.

THE registered additions to the Society's Menagerie during the month of June were 295 in number. Of these 144 were acquired by presentation, 35 by purchase, 56 were received on deposit, 15 in exchange, and 45 were born in the Gardens. The following may be specially mentioned:—

One Pudu Deer (*Pudu pudu*), from Chili, and two Patagonian Cavies (*Dolichotis magellanicus*), from Patagonia, presented by Mr. Albert Pam, F.Z.S., on June 2nd.

Three Pumas (*Felis concolor*), born in the Menagerie on June 13th.

Two Canadian Beavers (*Castor canadensis*), from Canada, received in exchange on June 5th.

One Savanna Sparrow (*Passerculus savannah*), from North-East America, new to the Collection, purchased on June 18th.

One Ceylon Mynah (*Acridotheres melanosternus*), new to the Collection, presented by Dr. Philip H. Bahr, F.Z.S., on June 29th.

One Golden-fronted Woodpecker (*Melanerpes flavifrons*), from Brazil, new to the Collection, purchased on June 5th.

One Calthrope's Parrakeet (*Palaeornis calthropae*) from Ceylon, new to the Collection, deposited on June 29th.

One Condor (*Sarcorhamphus gryphus*), from Chili, presented by Mr. Albert Pam, F.Z.S., on June 2nd.

Two Crested Screamers (*Chauna cristata*), bred in the Menagerie on June 19th.

Two Sun-Bitterns (*Eurypyga helias*), from South America, purchased on June 16th.

One Kagu (*Rhinochetus jubatus*), from New Caledonia, received in exchange on June 27th.

Two Spiny-tailed Skinks (*Egernia depressa*), from Australia, new to the Collection, purchased on June 10th.

A collection of Snakes from Sierra Leone, including three Sooty Snakes (*Boodon fuliginosus*), new to the Collection, presented by Mr. Guy Aylmer, F.Z.S., on June 18th.

A collection of Snakes from India, including one Forsten's Tree-Snake (*Dipsas forstenii*), new to the Collection, received in Exchange on June 2nd.

Two Gopher Frogs (*Rana aesopus*), from North America, new to the Collection, received in exchange on June 2nd.

XUM

THE HAIRS OF ANIMALS.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C., and R. MORRIS PRIDEAUX, F.I.C.

THE study of the hairs of animals has been singularly neglected, notwithstanding the many questions of scientific interest that it involves. With the exception of silk and wool, which now have a fairly full literature of their own, little will be found in textbooks about other animal fibres and the curious differences in structure shown by the hairs of different species of animals. In the present article, therefore, we wish to give a general outline of the nature of hair, together with some account of observations that have been made by us and not hitherto published.

In the popular view, wool and hair are usually regarded as something quite distinct, but the difference is one of degree rather than of kind. Wool may be defined as a particular variety of hair of fine texture characterised by having a more or less curled form and a surface covered with scales which tend to overlap each other. As a rule there is no medulla.

This distinction between hair and wool is by no means sharp, and it is not uncommon to find the same animal producing both types of fibres. For example, in the hair of the goat there is a lower layer of woolly fibres, and a similar mixture of the two sorts of fibre may be observed in the coats of certain breeds of dogs, such as the Bedlington terrier (Figure 299).

In the case of the Siberian sheep the nature of the hair varies with the seasons, the coat being of a hairy type in the summer, but changing to wool in the winter. The predominance of woolly fibres in the coats of ordinary breeds of sheep is largely the result of the animals having been kept for generations under exceptional conditions, and of special breeding to produce this result. When the ordinary domestic sheep is allowed to run wild, it will in the course of a generation or so produce a fleece containing a large proportion of straight fibres.

The character of the scaling upon wool is an important factor for distinguishing between the products of different breeds. For example, in the wool from the merino sheep, the scales go round the fibre, so that the microscopic appearance suggests that of a Malacca cane, with closely set joints (see Figure 295), whereas in the wool from cross-bred sheep the scales are smaller and cover only a small section of the axis of the fibre (see Figure 296). In healthy wool the scales cover the area of the fibre completely, but in certain diseased conditions the cortex will appear bare in patches. It is not uncommon, however, to find in the wool of lambs that have not yet been shorn numerous fibres from the tips of which the scales have been completely stripped by friction (see Figure 297).

The scales on the hair of animals are best examined by oblique illumination by throwing the iris diaphragm out of the optical axis of the instrument. This causes the projecting edges of the scales to catch the light in such a way that they stand out clearly.

The number of scales on a given area varies greatly. For example, Hanausek found that in one millimetre length the number of scales showed the following variations:—

Sheep's Wool (ordinary)	97	White Alpaca	90
„ „ (merino)..	114	Brown „	150
„ „ (Saxony)..	121	Vicuna...	100
Angora Wool	53	Camel's Hair	90

The cortex or surface beneath the scales frequently shows longitudinal streaks, and in the coarser types of hair a medulla or central canal may be present. This medulla may be continuous along the length of the fibre, or it may show interruptions in places, or stop abruptly. It often shows cells of characteristic form, while in other cases it is made up of granular particles. It is best examined under the microscope, with the iris diaphragm reduced to a small aperture.

Frequently it will be found that when both woolly and hair-like fibres are produced by the same animal, the former show no indications of a medulla, whereas the latter have a pronounced medulla. A good instance of this may be seen in the hair of the Cashmere goat and in that of some of the small American goats. In vicuña fibres from *Auchenia vicuna*, fine woolly hairs without medulla predominate, whereas in alpaca hair from *Auchenia paco* most of the fibres are coarse and show a medulla.

The wavy structure of woolly hairs, which is most pronounced in the finest varieties of sheep's wool, appears to be due to contractions, which are caused by the cells upon the cortex being uneven. In types of wool which approximate more nearly to hair, as, for example, that of the Angora goat or mohair, there is only a slight tendency towards curling.

Another point to which attention must be given in differentiating the fibres of different species of animals is the distribution of the pigment in the cortex. In studying this feature under the microscope as much light as possible should be transmitted through the fibres. This will cause all signs of

XUM

medulla and scaling to disappear, but will render the disposal of the pigment very distinct.

In the case of sheep's wool, fibres containing black or brown pigment are relatively uncommon, whereas in the hair of the camel and many other animals, they are of frequent occurrence.

Arrangement of the pigment in dashes or lines, or in a congeries of dots, is often characteristic of the hairs of particular animals, as may be seen by reference to the illustrations of the hairs of the bears and some of the apes. The Himalayan goat or serow produces hair (see Figure 298), which may be taken as typical of the bristle type of fibres. Among the hairs will be found some so heavily charged with pigment that in places they are quite opaque. Other bristles, however, of equally coarse character contain but little pigment. In both these types of fibres the medulla is very pronounced (A), nearly down to the base, while in the dark-coloured fibres the pigment extends nearly the length of the hair (C). In some of the fibres of a less coarse nature there is no medulla, and the scaling is less pronounced.

From what has been said the general points to be studied in examining the hairs of animals will be readily understood, but it may be of interest to amplify our remarks by reference to the fibres of particular animals, and especially those of allied species.

In the hair of the dog, as in the case of sheep's wool, considerable differences will be found in the fibres produced by different breeds, the wire-haired dogs having hair of different type from the silky-haired dogs. In the woolly hair of the Bedlington terrier, to which allusion has already been made, the scaling projects and no medulla is visible, so that the general appearance of the fibre resembles the wool of an Angora kid (see B, C, Figure 299). The stoutest type of hairs (D) are of a bristly character and show a pronounced medulla, while intermediate between these extremes are fibres showing an interrupted medulla, fine scaling, and faint longitudinal markings.

It is interesting to note that the coat of the native Australian dog, the dingo (see Figure 300), has fibres of the three types and shows to an even more pronounced degree an analogous cellular structure of the medulla.

On the other hand, the few remaining hairs of the Mexican hairless dog (see Figure 301) show a very different structure. In the fibres without medulla the surface is covered with fine scales, resembling that upon the hairs of some of the apes, while the other fibres have a very coarse medulla which does not show the cellular structure usually found in the hairs of ordinary breeds of dogs.

In the fur of the wolf (see Figure 302) the cellular structure of the medulla is apparent in some of the fibres, whereas in others there is a very broad continuous medulla. In the former the scaling causes the edge of the hair to appear sharply serrated, while in the latter the edge is nearly smooth and the scaling very fine. The type of fibres marked A is intermediate between these extremes.

Wide variations in structure are also shown by the hairs of the African jackal (see Figure 303). These include coarse black and white bristles, having an opaque medulla (A) and ending in a fine point (B), and fine woolly hairs which are well covered with scales. In the latter the medulla, which in places has a chain-like appearance, stops near the apex, where the fine scaling resembles that of merino wool.

Similarly, in the fur of the fox (see Figure 304) the fibres contain a small proportion of bristles having a wide medulla which becomes intermittent towards the tip, which ends acutely (C). Most of the hairs, however, are soft and curly, with scales projecting from the edges, and this, in conjunction with the structure of the medulla, gives to the fibre the appearance of a jointed chain.

Coming next to the cats it will be noticed that in the fur of the domestic cat, the fibres end in a very fine point, while the scaling is well marked, and all show a medulla which here and there is interrupted. In the full-grown animal the medulla may be wide and show a reticulated structure (C, Figure 305), but in the case of the kitten the hairs have projecting scales and a medulla made up of a series of single cells.

It is interesting to note that the leopard shows fibres of an analogous character, the medulla in some being wide and continuous (see Figure 306), while in others, which show fine scaling, it is intermittent. Examples of the unicellular structure of the medulla seen in the hair of the common kitten may also be found.

Mention may also be made here of the so-called sea-cat of Chili, which is valued for its fur. The fibres are of the most variable type. On the fine hairs the scales are very prominent but not plentiful, and in some cases (C) project so much as to give a feathery appearance to the hair. The fibres terminate in a somewhat blunt point, and have a medulla which ends near the base (see Figure 307).

The reticulated structure of the medulla which is shown by some of the fibres of the cat is much more pronounced in the hair of the brown rat (see Figure 308). These are of the bristly type, with scaling well marked towards the base, and end in an abrupt point.

Examples of hairs from the fur of different species of bears are shown in Figures 309–311.

In the fur of the Himalayan bear some of the fibres are dark brown and very opaque, while others are

FIGURE 295.
Merino Wool.

FIGURE 296.
Irish Wether.

FIGURE 297.
Lamb's Wool.

FIGURE 298.
Himalayan Serow ?.

FIGURE 299.
Bedlington Terrier.

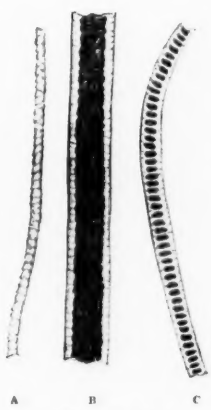

FIGURE 300.
Dingo Puppy.

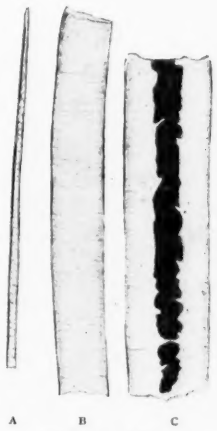

FIGURE 301.
Mexican Hairless Dog.

FIGURE 302.
North American Wolf.

FIGURE 303.
African Jackal.

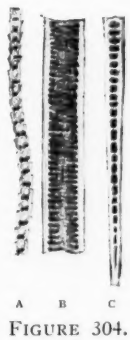

FIGURE 304.
Common Fox.

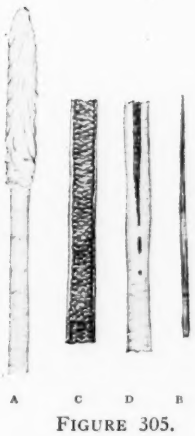

FIGURE 305.
Cat.

FIGURE 306.
Nigerian Leopard.

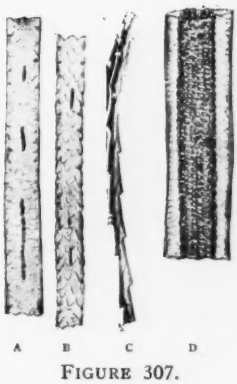

FIGURE 307.
Sea Cat.

HAIRS OF ANIMALS × 104.

HAIRS OF ANIMALS × 104.

FIGURE 308.
Brown Rat.

FIGURE 309.
Himalayan Bear.

FIGURE 310.
Russian Bear.

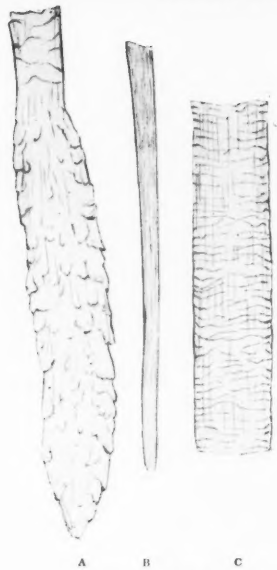

FIGURE 311.
Sloth Bear.

FIGURE 312.
Kangaroo.

FIGURE 313.
Rabbit.

FIGURE 314.
Sable Antelope.

FIGURE 315.
Human Hair.

FIGURE 316.
Young Chimpanzee.

FIGURE 317.
Old Chimpanzee.

FIGURE 318.
Orang Utan.

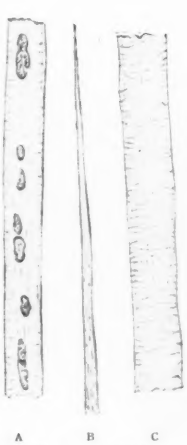

FIGURE 319.
Gibbon (hind foot).

FIGURE 320.
Human Hair (axillary).

FIGURE 321.
Hair of Negro.

paler and show well-marked scaling and an ill-defined medulla.

The Russian bear also shows the two kinds of fibres, but the medulla, when present, is much more pronounced.

In the hairs of the sloth bear the medulla is usually absent. The pigment is deposited in lines in the same way as in the hair of the other bears, while in the central portion of the fibre the scaling is close and well marked.

Hairs of very distinctive types are shown by the kangaroo (see Figure 312) and the rabbit (see Figure 313), the structure of the medulla and the scaling being very characteristic in each case.

A single example of the hair of the antelopes is given (see Figure 314) which shows two portions of a fibre from the coat of a Rhodesian sable antelope. The hairs are long and coarse and show a broad opaque medulla extending from the base nearly to the tip (A). The scaling on the cortex is fine but well defined.

There is no difficulty in distinguishing between human hair and the hair of any of the lower animals, but the numerous points of resemblance between the hairs of allied species of animals suggested the possibility that man's nearest relation among the animals might also show analogous resemblances to human hair.

Apart from its scientific interest, the point is of practical importance, since it is frequently necessary in forensic work to ascertain whether a particular hair belonged to a human being or to an animal.

To investigate this question we have made a study of widely differing types of human hair, and have compared them with the hair of some of the principal species of anthropoid apes.

The hair shown in A, Figure 315, was taken from the head of a newly-born female child, and it is remarkable that the fibre has many more points of resemblance in common with the hair of some of the lower animals such as the merino sheep, than are to be found in adult human hair. Thus on the hair of the young child (B) the scales are very scanty, while in adult human hair they become more numerous and more compressed. There is also a tendency towards a jointed structure, which disappears in the hair of the adult (see C, Figure 315).

In the hair of the young chimpanzee (see Figure 316) it will be noticed that one of the fibres (B) resembles the hair of the young human child, with the exception that the scaling is less pronounced; but in the other fibre (A) there is a clear medulla. Again, in the hair of the old chimpanzee (see Figure 317) it will be seen that part of one of the fibres, near the base, resembles adult human hair, but that here, again, the scaling is less pronounced than on human hair. In this hair, however, a medulla interrupted in places will be found, while at the top the disposal of the pigment differs from that usually found in human hair.

The hair of the orang utan (see Figure 318) and of the gibbon (see Figure 319) also shows points of resemblance to human hair, but there are also many distinguishing features.

A medulla is much more common in the hair of the higher apes than in European human hair. In a lecture to the Selborne Society it was stated by one of us (Mitchell) that apparently a medulla was not formed in human hair.

Since then our investigations have led us to modify this statement considerably.

It occurred to us that since the axillary hair in man is probably a vestige of his former ancestry, it was in such hair that a medulla would be most likely to be found. This was confirmed by a study of the hair from the human arm-pit (see Figure 320). In some of these hairs there was a narrow irregular medulla (A), with dots of pigment, but no scaling visible, while others equally stout showed no medulla, but were covered with fine scaling which was well marked near the base.

The remarkable result of this examination led us to examine the hair of a negro, in which it appeared probable that the relationship between the hair of man and the apes might be traced more closely than in the case of European human hair. The result is shown in Figure 321.

The fibres were coarse, and usually showed a narrow medulla, which in some cases was continuous throughout the whole length of the hair.

The pigmentation was so pronounced in some of the fibres as almost to obscure the tract of the medulla, while other hair contained a much smaller amount of pigment. Apparently the amount of pigment had no bearing upon the occurrence of a medulla. In all the fibres the scaling was ill-defined.

A comparison of these hairs with the hair of the apes, especially the orang utan, shows how close are many of the resemblances. In fact, it appears justifiable to conclude that the hair of the negro resembles that of some of the higher apes much more nearly than it does the hair of the average European.

We intend to continue the study of this interesting branch of our subject, and should be grateful if any reader of "KNOWLEDGE" would forward to us any authenticated specimens of hairs of out-of-the-way races of mankind.

NOTE.—All the illustrations are drawn to the same scale of magnification (104 diameters).

XUM

CORRESPONDENCE.

MARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your issue of June there appeared on the above subject a letter, signed J. E. Maxwell, which contains so many errors and misrepresentations that their complete refutation seems to me necessary.

In the first place there is a confusion in the very purpose of that paper, since its author chiefly disagrees with me on an idea of mine which he himself adopts. It is stated in my article, on pages 193–196, that although there are no straight lines on Mars, yet this truth would not be accepted without opposition, and that the astronomer of the *future* will sneer at these wonders. Hence I made it quite clear that my arguments and proofs had not yet secured *public* recognition, and that, consequently, at present they are not established truths. Yet the author of the letter in question, in his anxiety to contradict, overlooks that he appropriates my idea by proclaiming that my views "are not established truths." But even otherwise considered, the argument has no bearing; for when an investigator is sure that he enunciates the truth, he cannot but remain utterly indifferent to the acceptance, or temporary non-acceptance, of his results by the public.

The correspondent in question next says that he has never before seen it stated that "canals" appear "straight and not curved at the edge of the disc." And yet canals are drawn straight near the limb by Schiaparelli, Perrotin, Terby, Guiot, Wilson, Cerulli, Lowell, Douglass, and others. Further, from one of the numerous papers in which this peculiarity was pointed out, I shall quote a passage in "KNOWLEDGE" for 1894, page 250, where we find that "the 'canals' when near the edge of the disc are apt to be represented as much straighter than they could possibly be." With ordinary care and prudence such public display of unaquaintance with the subject treated could easily have been avoided.

Another glaring oversight is the assertion that "no markings . . . can be seen near the limb of Mars, owing obviously to the planet's atmosphere." That this is just the reverse of reality is proved by the photographs, which show all dark markings quite as intense near the limb as near the centre of the disc. The apparent character of the bright limb, due to contrast with the dark sky, is naturally not even suspected here.

There is nothing extraordinary in the fact that Mr. Denning discovered the true nature of the minor detail on Mars with a ten-inch, while Mr. Lowell failed to do so "with his twenty-four-inch." For, to say nothing of the superior ability and experience of the former of these two observers, the effective difference between their telescopes is not the difference of ten and twenty-four, as erroneously pointed out on pages 238, 239, but the difference between ten inches and thirteen and a half inches, since this last is the usual aperture to which the twenty-four-inch is stopped down on Mars.

The writer of the letter quoted next fails to understand the effect of magnification of a planetary disc on the sharpness of its markings. Yet nothing can be clearer. Inasmuch as the fine lines flashing on Mars are usually flashing on a disc having the apparent size of a sixpenny piece held at the distance of two feet from the eye, they ought to be represented quite sharp on such a small disc held at the above distance. But on a three-inch drawing, seen at one foot, the sharpness would cease, just as the sixpenny piece enlarged photographically to six inches would show nothing but very vague details. Should further corroboration be needed on this point, it could be found on the best photographs of Mars, which, while revealing more delicate detail than any ever drawn prior to 1909, yet show all markings diffuse on a disc smaller than one inch in diameter.

On page 239 doubt is cast on the fact that the narrow straight lines on Mars are seen only by glimpses. Here, again, we have a confusion of the straight fine lines with the diffused streaks, held steadily. My experience, like that of Terby and others, is that the lines are always flashing for a small fraction of a second; and as this was also Schiaparelli's experience, I shall be excused if I accord a greater weight to the Martian observations of Schiaparelli than to those of an unknown amateur.

With regard to Figures 190 to 193, page 194, we are now asked to believe that the structure of the planet was geometrical and furrowed with straight lines on 1909, September 18th; that it was natural and irregular, without lines, two days later, on September 20th, and also on October 5th; and that it was again geometrical with straight lines on November 3rd. The manifest impossibility of such an assumption proves that my drawing, corroborated, as it is by Professor Hale's wonderful photograph, shows Mars practically as he is (so far as our present optical means go), and that the rude sketches of Mr. Lowell and M. Jarry-Desloges, which fail to reveal the coarser details, break down altogether under the crucial and unanswerable test of photographic comparison. Behind the impersonal confirmation of photography, I am awaiting all critics with a smile; and the overwhelming superiority of large telescopes, displayed every day on double stars, and by the spurious satellite to Sirius discovered at Mr. Lowell's observatory, thus receives an additional, though useless, corroboration.

I granted some years ago, and still grant, that Flagstaff may enjoy the finest atmospheric conditions for astronomy. But as the aperture there is some thirteen and a half inches, Mars is defined in Arizona as if he were from two and a half to three times more distant than in the three largest refractors of the world. This is the reason for which a few seconds of perfect seeing at Yerkes, Lick, Meudon, or Mount Wilson have done more for the recognition of the true character of the Martian spots than the laborious canal records of nine whole apparitions at Flagstaff. Does the correspondent know that the arëographer who drew more straight lines on Mars than any other—Professor A. E. Douglass—in a visit paid me in 1910, declared all the canals which he was seeing for years with Professor Lowell's very telescope at Flagstaff to be illusive.

Discussions on such a one-sided affair as the canal question are, of course, useless. Yet the present letter, besides refuting opposition, has also rendered clear the position of the believers in the linear canals, which is: (*a*) that, within certain limits, the more distant a heavenly body is from the observer, the better he distinguishes the details of its surface; (*b*) that, within wide limits, the greater the confusion of vision of an object, the sharper its perception; and (*c*) that the laws of perspective, on which our knowledge of the universe stands, are wrong.

When the defenders of a theory are reduced to question the truth of natural law for its support they merely betray the rout of their reasoning.

E. M. ANTONIADI.

PARIS.

HEN BIRDS WITH MALE PLUMAGE.

To the Editors of "KNOWLEDGE."

Sirs,—Regarding the statement by your correspondent (the Director of Melbourne Zoölogical Gardens) that hen-pheasants and so on, assume the plumage of the male bird under certain conditions, it may interest your readers to know that when visiting Folkestone Museum a few years ago I saw there a stuffed specimen of a cockerel which a card near explained had formerly worn hen plumage, and even laid eggs. The bird had been the property of a farmer in the vicinity whose name is attached to the card.

A. ATKINSON.

HARROGATE.

SOME NOTES ON THE HISTORY AND SIGNIFICANCE OF THE THEORY OF SPONTANEOUS GENERATION.

By H. STANLEY REDGROVE, B.Sc. (Lond.), F.C.S.

A BELIEF in the spontaneous generation of such forms of life as mice, maggots, lice, and other vermin out of dirt and decayed organic matter was at one time universally held, and was explicitly taught by Aristotle (see the fifth book of his "History of Animals"). The first work of importance to throw doubt on this theory was done in 1668, when the Italian Redi showed that no maggots were bred in meat, if flies were prevented from laying their eggs on it. In 1683, however, A. van Leeuwenhoek discovered, by the aid of the microscrope, those forms of life, invisible to the naked sight, that are known as "bacteria." This discovery seemed to give considerable support to the doctrine of spontaneous generation, or abiogenesis (as it is now generally called), it being found that, however carefully bodies of organic origin were screened from contamination by outside sources, bacteria invariably made their appearance in them. In the middle of the nineteenth century, however, Pasteur found that if the bodies were first sterilised by heat and prevented from coming in contact with any air other than that which had also been sterilised, no bacteria were developed: milk, for example, he found would keep good for any period in these circumstances. Pasteur's results are accepted by practically all modern biologists and bacteriologists. Professor Charlton Bastian,* however, has more recently carried out numerous experiments with results apparently altogether opposed to those of Pasteur. Indeed, he states that he has obtained growths of bacteria and torulae in inorganic saline solutions containing sodium silicate or colloidal silica (preparations of mineral origin) which had been completely sterilised by heat and preserved in hermetically sealed tubes. It is evident that abiogenesis must have taken place at some period of the world's history, for certainly no life could have existed on the earth when it was in a molten condition; and if one argues (as has been done) that life was first conveyed to this earth by meteorites from other planets, apart from the intrinsic difficulties of this theory, it merely transfers the problem of the origin of life to another planet without in any way simplifying it. Given the right conditions, therefore, there seems no valid reason why spontaneous generation should not take place now; though it is, perhaps, difficult to understand how organised forms of life, such as bacteria, could be immediately produced from inorganic matter; but, as Professor Bastian indicates, the production of the bacteria and torulae in his experiments may have been preceded by the formation of ultra-microscopic specks of unorganised life. Another question that may be asked in connection with these experiments arises out of the fact that protoplasm, which is the material basis of all forms of life, contains carbon as one of its essential elements. Must we assume that a transmutation of the elements occurred in Professor Bastian's experiments? Or is it possible for silicon to take the place of carbon in protoplasm? However, Professor Bastian's results have not met with general acceptation. It is a pity that his experiments are not repeated by other competent biologists; some degree of certainty in the matter might then be obtainable.

In 1905 Mr. Butler Burke thought he had succeeded in obtaining living "cultures" by the

* In Professor Bastian's experiment *very* dilute solutions of sodium silicate containing either (i) a few drops of ***liquor ferri pernitratis*** (ferric nitrate solution) or else (ii) a very small quantity of ammonium phosphate and phosphoric acid were placed in sterilised glass tubes and hermetically sealed. They were then heated to temperatures varying from 115° C. to 145° C., and afterwards exposed to diffused sunlight. After several months they were opened, and the sediment formed by the chemical reaction between the salts when the solutions were heated was examined microscopically. Microphotographs (× 700) of various examples of organisms either observed in the sediment or cultivated therefrom are shown in Figures 325–330, which are reproduced on page 292 from "The Origin of Life: being an Account of Experiments with certain superheated saline Solutions in hermetically sealed Vessels" (Watts, 1911, 3s. 6d. net), by kind permission of Professor Bastian. These figures are as follows:—

FIGURE 325. Solution (ii). Heated to 130° C. for 10″. Mass of Torulae ("Yeasts").
FIGURE 326. Solution (ii). Heated to 135° C. for 5″. Group of vacuolated Torulae.
FIGURE 327. Solution (ii). Heated to 135° C. for 5″. Bacteria.
FIGURE 328. Bacteria cultivated from tube shown in Figure 327 as found on ninth day.
FIGURE 329. Solution (ii). Heated to 130° C. Mass of Torulae with four Bacteria. Cultivated (ninth day).
FIGURE 330 (from the Second Edition of "The Origin of Life"). Solution (i.). Heated to 100° C. for 20″ on three successive days. Mould of *Streptothrix* type. (× 300).

In the case of the experiments, the results of which are shown in Figures 327–329, Graham's pure colloidal silica was used in place of sodium silicate. It was found necessary to use freshly prepared silica or silicate solution.

It is interesting to know that in control experiments, in which the tubes were opened within a day or two of sealing, no organisms were observed.

XUM

action of radium salts on sterilised bouillon, and his experiments produced a "nine days' wonder" at the time. Mr. Soddy, however, showed shortly afterwards that the phenomenon was of a purely chemical nature, no living matter being produced.

Quite recently, Professor Leduc has described certain inorganic preparations (called "osmotic growths") which resemble living bodies in some respects. An "osmotic growth" may be obtained by dropping a piece of a soluble calcium salt into a solution of carbonate, phosphate, or silicate. The dissolving calcium salt is diffused into the solution and produces an insoluble carbonate, phosphate, or silicate of calcium, forming a colloidal membrane around the partly dissolved calcium salt. This membrane offers far more resistance to the passage of dissolved salt than it does to that of water. Hence pressure is set up and water flows into the membrane, distending it until all the calcium has been used up and the membrane can no longer bear the pressure. The phenomena resemble, in a way, those of growth and assimilation of nutriment as exhibited by living beings, and the distended membranes assume forms not unlike those of certain species of marine life. It is only by a stretch of imagination, however, that we can speak of such "osmotic growths" as possessing life; but they do help to illustrate the difficulty there is of drawing a hard-and-fast line between living and non-living matter. (See Figures 322–324.)

Seeing that life as manifested in this world is always associated with protoplasm, the suggestion readily arises that protoplasm, so to speak, is naturally alive; that the chemist has only to synthesise this body in order to produce living from non-living matter. A good deal of attention has been drawn to this theory by Professor Schäfer's recent presidential address to the British Association on the origin of life. But the theory is not a new one. Similar views have been expressed by Professor Haeckel; and the present writer in 1909, as the result of a somewhat different manner of viewing the question, expressed a conviction that chemists had only to synthesise protoplasm in order to produce living matter.* This synthesis has not yet been carried out, but no doubt it will one day be brought about. Since the day in 1828 when Wöhler first synthesised urea from ammonium cyanate, and thus broke down the artificial (though convenient) distinction between inorganic and organic bodies, chemists have succeeded in building up from simpler forms of matter an enormous number of bodies hitherto only obtainable from animals and plants; and everything indicates that the progress of chemistry will continue until all organic products will be included in this category.

Does this view of the subject, however, justify us in holding a purely materialistic view of life, as some biologists (*e.g.*, Professor Sir E. Ray Lankester) seem to believe? The reply to this question depends largely upon what we mean by life, Professor Schäfer is very careful in his address, already referred to, to indicate that by "life" he does not mean "soul"; and one cannot help contrasting his cautious and scientific attitude in the matter with the somewhat unscientific impetuosity of Professor Sir E. Ray Lankester, who has informed the readers of the *Daily Mail* that for him this distinction does not exist. Considered purely as a phenomenon occurring in the physical realm, one is certainly justified in looking for a scientific, that is, a mechanistic (or materialistic, if one so pleases to term it) theory of life. But this is not the last word on the subject. Metaphysics begin where physics leave off, and the problem of life still exists for the philosopher when it has been solved by the man of science.

Looked at genetically, living matter, as we have indicated, appears to differ but slightly from that which is called non-living: the one seems to merge into the other. So must we look at life to understand it scientifically. But to understand life philosophically we must look at it when most highly developed or (to speak more accurately) manifested: not at the moment of its birth. In other words, we must study *man*. And here the distinction between the living and the non-living becomes manifest. Matter—non-living matter—is essentially inert. Man is essentially active. So far as low forms of life are concerned, the biologist may explain their apparently spontaneous activity as the result merely of reflex action; that is, as the reaction to forces operating from without, and thus involving nothing opposed to the characteristic inertia of matter. But psychology forbids us to believe that man, though subject to outside influence, is moved only from without. In fact, considered philosophically, the problem of life becomes the problem of soul and consciousness; and it is then evident that no materialistic explanation is possible. For, since matter is known to us only in terms of consciousness, the attempt to explain consciousness in terms of matter at once places us in a vicious circle from which there is no escape save by repudiating our materialism.

There seem to be only two alternatives, (i) the universe is unintelligible, or (ii) all things are the product of "spirit" (if I may use this term to designate that reality whose characteristic property is consciousness); and the first of these alternatives, I think, is put out of court by the fact that as our experience widens so do we find the universe increasingly intelligible.

Looked at from this standpoint, then, matter is the first and lowest product or manifestation of spirit. As such its properties seem to contradict those of spirit. As such it is inert and lifeless. But, itself the product of spirit, it forms the vehicle for increasingly full manifestations of spirit. The degree of manifestation depends upon the form and complexity of the matter. At the protoplasmic stage of evolution the manifestation begins to exhibit

* See the present writer's "Matter, Spirit, and the Cosmos" (Rider, 1910), Chapter IX, "On the Origin of Life."

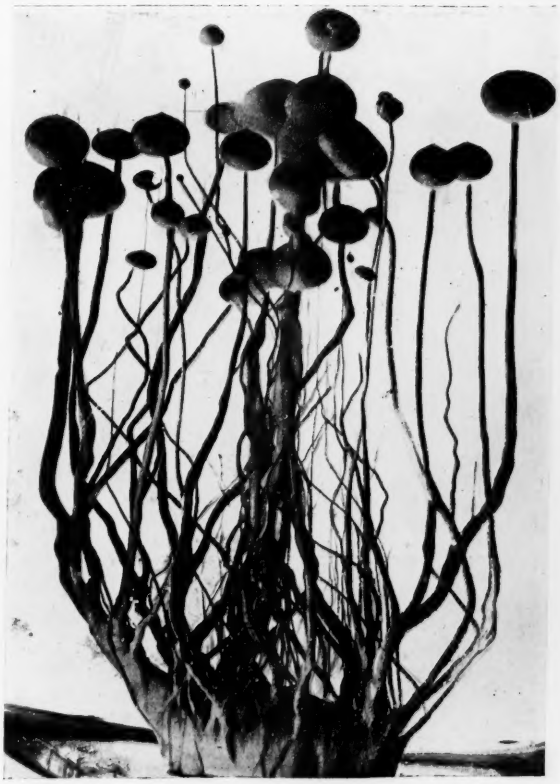

FIGURE 322.

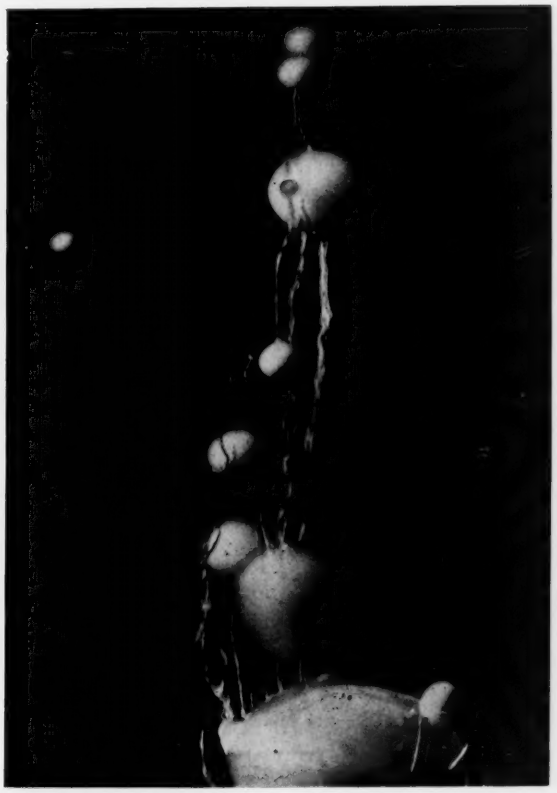

FIGURE 323.

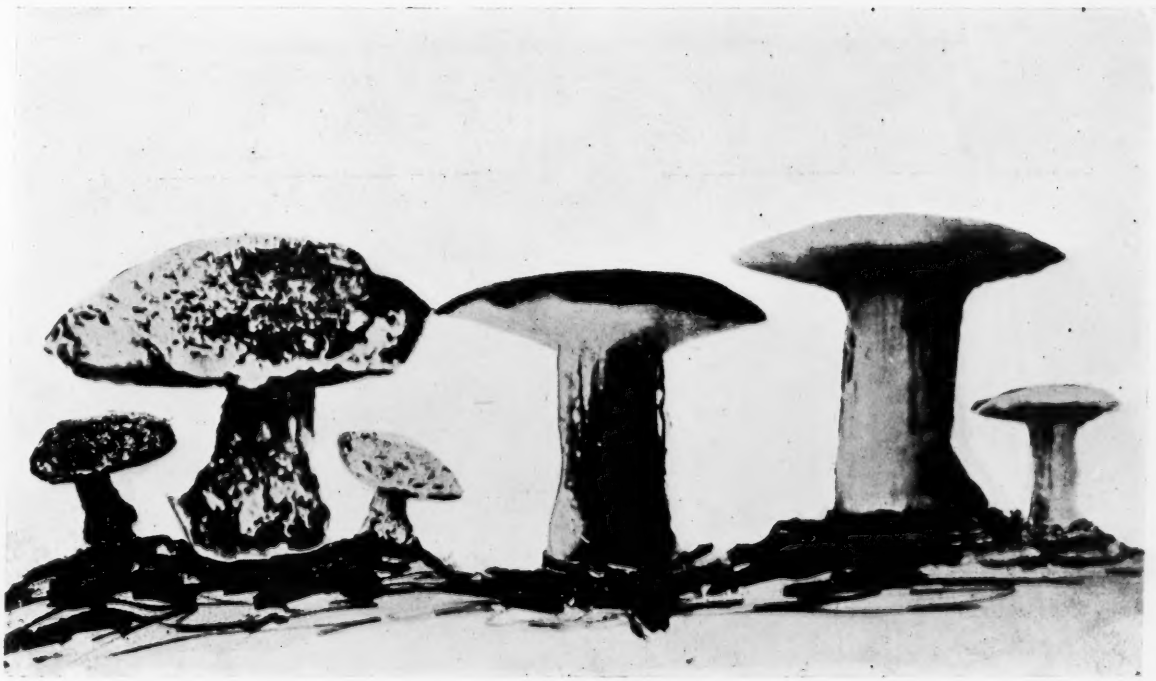

FIGURE 324.

Osmotic Growths reproduced from "The Mechanism of Life," by kind permission of Dr. Stéphane Leduc.

XUM

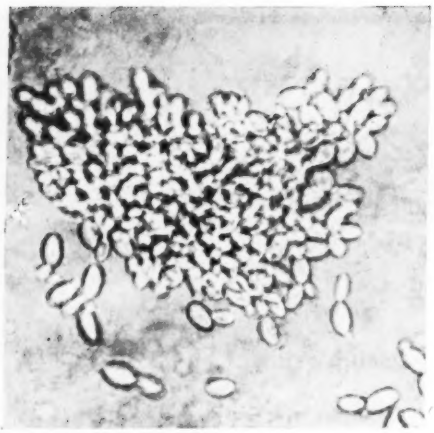

FIGURE 325.
Torulae (Yeasts).

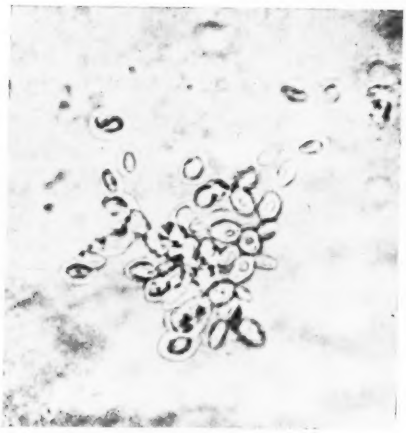

FIGURE 326.
Vacuolated Torulae.

FIGURE 327.
Bacteria.

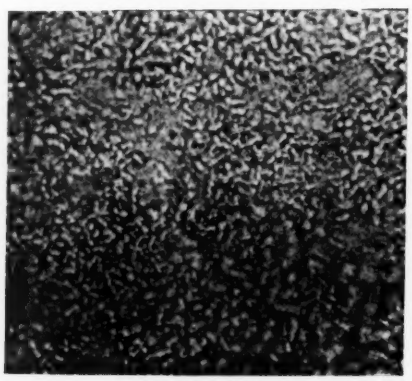

FIGURE 328.
Bacteria cultivated.

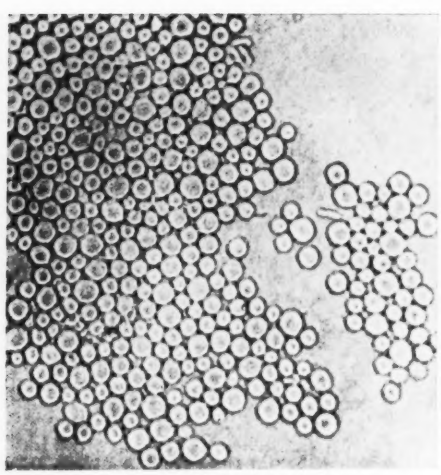

FIGURE 329.
Mass of Torulae.

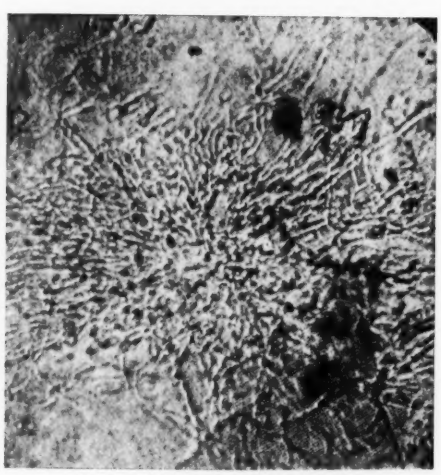

FIGURE 330.
Large Mould (*Streptothrix*).

ORGANISMS OBSERVED IN PROFESSOR BASTIAN'S EXPERIMENTS.

the properties of spirit more clearly than heretofore, and we call the matter "living" because we recognise the kinship between its spirit and that which we call "ourselves." The *raison d'être* and purpose of the whole process is, I believe, the differentiation of homogeneous spirit into individual, self-conscious units or souls capable of true happiness—the one thing of absolute value. This is only perfectly achieved in man. Of course, a theory so wide and comprehensive as this deserves more than the bald statement here alone possible. I have attempted a fuller statement, though very inadequately, in the essay already referred to; and I must also refer the reader to the remarkable metaphysical treatise of the Swedish philosopher, Swedenborg, entitled "The Divine Love and Wisdom," which is the chief source of these views concerning the ultimate significance and nature of life. My primary reason for calling attention to the theory here is to indicate how entirely it fits in with the doctrine of evolution and the latest scientific view concerning the possibility of the spontaneous generation of life.

CORRESPONDENCE.

THE NUMBER OF "DOUBLE" STARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your number for June, on page 239, Mr. E. Holmes criticises a correct statement of the late Mr. F. W. Henkel as to the number of known double stars. The words he quotes are: "Perhaps as many as twelve thousand such couples are known." I take exception to his criticism; the most correct word of these ten is *perhaps*. Further, the expression "standard authority" is out of place; there is no *one* standard authority. Let me explain. The branch of astronomy known as "double stars" (two stars in close juxtaposition as viewed from the earth) has become very expansive since I commenced observing double stars in 1881; the great increase in the optical power of recent telescopes has brought thousands of optical pairs of stars upon record. The chief merit of these modern observations is that they are made with the finest instruments and most skilled observers in this branch; many of these observations are duly recorded in Mr. Burnham's "Magnum Opus," in 1170 pages, and the total number of double stars which he gives therein is thirteen thousand six hundred and sixty-five (not fifty-five, as given by Mr. Holmes). This work was published in 1906 by the Carnegie Institution of Washington.

But of what does this consist? I opened this catalogue at random and it happened to be page 112; this is what is there (with thirty-three properly observed pairs):—

No.	Position Angle.	Distance.	Magnitudes.	Year.
5564	116°·3	15″±	8–9, 11	1830+
5568	331 ·8	7 ±	11 = 11	1834·3
5575	305 ±	20 ±	6 17–18	1820+
5577	70 ±	2 ±	13 14	1820+
	305 ±	25 ±	15	1820+
5578	53 ·8	4 ±	10–11, 11–12	1830+
5587	69 ·4	25 ±	9–10, 10	1830+
5588	...	...	9 ...	...
5589	35 ±	12 ±	11 12	1828+
5593	210 ±	135 ±	5 ...	1873·29
	130 ±	5 ±	9·0 10·0	1873·29
5596	...	Cl. IV	8 11	...
5601	22 ·5	15 ±	10–11, 14	1830+
	208 ·0	18 ±	14	1830+
5602	...	Cl. IV	8–9 10	...
5607	...	Cl. IV	8 11	...
5609	130 ±	15 ±	9 10	1820+
5610	...	33 ·27	... ...	1783·09
5611	...	...	9·1 ...	1902·
5612	139 ·0	15 ±	9–10, 11	1830+

Upon referring to Vol. II (notes) I find there is no further information given to Nos. 5568, 5577, 5578, 5596, 5602, 5612; to Nos. 5564, 5575, 5587, 5593, 5611 there are recent and accurate measures given; therefore the Herschel approximations might have been abandoned and not again reprinted. They are already in Smyth's "Celestial Cycle" and Gledhill's "Handbook"; Nos. 5588, 5589, 5601, 5607, 5609, and 5610 have notes, and there seems no need to have again numbered them, nor to have included them in a good reference catalogue, except among the notes or in a table in the Introduction.

The general result is that on page 112 there are fifty pairs of stars: of these, seventeen are as just quoted in detail, none of which should have so appeared in an accurate and up-to-date catalogue, except as mere notes. The whole volume is similar to this, and the 13,665 pairs or double stars may be safely reduced by at least twenty-five per centum, and we get about nine thousand pairs worthy of inclusion in the tabular catalogue: the R.A.'s and Declinations are given for an old epoch (1880). Then this only includes stars to minus thirty-one degrees; none of Innes's valuable work, or of other southern observers, is included. So Mr. Henkel's "*perhaps* as many as twelve thousand such couples are known" is a statement not very far from the correct number at present published, mere estimations omitted. From Mr. Holmes's reference to other catalogues of double stars one is lead to believe that he is unacquainted with the contents of that excellent catalogue by Mr. T. Lewis, published also in 1906. While the catalogue of Mr. Burnham is collected from all or many sources since 1780, and is still far from complete or homogeneous in character—though a work of reference so far as it goes—that by Mr. Lewis is formed upon a definition plan, being based upon a systematic series of observations of about three thousand double stars by W. Struve, with which have been incorporated in detail all known and good observations until about 1904. Much valuable information upon the orbits of the more interesting ***binary*** stars is given—as also in Mr. Burnham's catalogue. So it may be truly called a standard work of reference for W. Struve's stars, and it will be used for many a year; it does not touch those modern pairs of bright stars with very faint stars within about 1″, observed with instruments of 25-in. to 40-in. object glasses. So much for the visual pairs, few of which are "binaries."

What of the spectroscopic binaries, which are of the greatest interest? Their known number is already considerable. None of these are as yet thought to be worthy of inclusion in a so-called ***standard*** catalogue of "double stars." Mere numbers will not make a standard catalogue; uniform quality, completeness, and up-to-date epoch and material is what we should expect.

OXFORD. F. A. BELLAMY.

P.S.—I should like to mention that this letter was written quite in ignorance of Mr. Henkel's death, and it was in type before I was informed of it.

THE AGE OF THE EARTH.

By E. JOBLING, A.R.C.Sc., B.Sc., F.C.S.

THE discovery of the embalmed corpse of one of Egypt's ancient kings or the unearthing of some hieroglyphic inscription apparently dating back to Biblical times, are items of information which, when they reach the public ear, awaken at least a transient interest in the probable antiquity of the one or the bearing of the other upon the history of the peoples of the world. The call of the past is an appeal to which few of us are really irresponsive, though in most the receptive faculty gets dulled by inactivity, due in large measure to the lack of that divination which sees interest in objects of almost everyday acquaintance.

To comparatively few, for instance, has it ever occurred that in the age and life-history of that world upon which they "live and move and have their being" is to be found a problem of keener and more lasting interest than either of the above. The indifference of the many to this question cannot nowadays be attributed to a prevalent unquestioning belief in the Scriptural computation which ascribed to the earth a longevity of between six and seven thousand years; for this form of mental paralysis is happily now a thing of the past. It can only be the absence of any acquaintance with the general trend of scientific thought which debars them from the very real pleasure to be derived from the story of man's endeavours to delve into the unknown.

After all, to determine the age of the earth is a far more difficult undertaking than to assign the mummified king to his position in the Egyptian dynasties or to unravel the hieroglyphics of a Babylonian column. The presence of a coin or inscription in the one or a scientific deciphering of the other solves the respective problems; but in the case of the earth the difficulties encountered are not so easily overcome. The shape of the earth has to be determined, its strata have to be laid bare, its oceans weighed, and a thousand and one other investigations satisfactorily completed before even the data are amassed by means of which we hope to realise the vast stretches of time that preceded the very earliest of historians. Stupendous as the obstacles are, however, sufficient is known already to fling into the misty past a beam of light powerful enough to reveal with tolerable certainty the features of the earth as they presented themselves, say, a hundred million years ago, and to dispel to some extent the darkness of an even greater antiquity, if we call to our aid a little justifiable hypothesis.

Already it has been hinted that only in quite recent times has the question been approached scientifically. Time was when "catastrophism" was the current idea, and men believed that the earth, and indeed the whole solar system, had suddenly sprung full-fledged into being at some ridiculously recent date. When, however, the foundations of geology came to be laid by Hutton and Lyell, the immensity of the time required for an orderly deposition of the sedimentary rocks or the elaboration of the organic world laid such hold upon their imagination that "catastrophism" was abandoned for the other extreme, "utilitarianism," which relegated the birth of the earth to the very beginning of time and refused to adopt any smaller chronological standard than an "eternity."

These somewhat ludicrous extremes are now, of course, replaced by more reasonable views, which owe their conception to the application of the modern scientific spirit and the ever-growing accumulation of experimental data. The iconoclast who assailed and overturned the above extravagant hypothesis was Lord Kelvin, then Sir W. Thomson, who, in the few years following 1862, published papers in which he proceeded by several physical lines of reasoning to an estimate of the earth's age so small comparatively as to make the then-orthodox geologists gasp with surprise and indignation. These estimates of his—historically interesting, if now perhaps obsolete—will be briefly dealt with first before attention is turned to other more reliable evidences advanced in recent years.

It would be as well, however, before discussing the theories if we first obtain a clear idea of the various phases of life-history through which the earth has passed in order that no confusion may subsequently arise as to the relative significance of the numerical values obtained.

Imagine, then, a vast molten globe—the product, we may take it, of the condensation of a nebular haze—rapidly rotating round the sun. The influence of the latter would be such as to develop vast tides in the liquid magma of the rotating body, one of which tidal waves, the late Sir G. Darwin suggested, might conceivably have assumed sufficiently large proportions as to disturb the stability of the whole, and to be itself trundled off into space, where it would continue to revolve around the remainder as the infant moon. Sir G. Darwin, by-the-by, has calculated the time which has elapsed since this separation to be fifty-six million years. Its birth-pangs over, what we now know as the "earth" starts upon its career as a separate member of the solar system. Probably soon after the moon's departure the earth had cooled enough to permit of the formation on the sea of magma of floating islands of scoria, which would assume larger and larger dimensions until the outer crust of the earth was entirely solid and what is called in the earth's history its *consistentior status* was inaugurated. Further cooling resulted in the condensation of some of the constituents of the atmosphere, which products would collect in

pockets on the surface, and thus the configuration of continents and oceans arose. Sooner or later, yet another era would be ushered in by the commencement of those processes of denudation and deposition which, throughout the long ages following, have reared new continents upon the ruins of the old, and which still manifest their slow-moving but irresistible activities before our eyes. At what period signs of life appeared and the earth first became inhabited we cannot stay to discuss, but must revert to our original theme.

I.—KELVIN'S THEORIES.

During mine-sinking operations it is noticeable that as the shaft penetrates deeper and deeper the temperature slowly and regularly increases. In different places the temperature-gradient is not the same; for external conditions necessarily disturb it in the topmost strata, and we have not yet delved deep enough to reach the lower regions where uniformity prevails. But from observations made an average can be taken, and from this it is possible to deduce mathematically an estimate of the earth's age. The problem resolves itself into the following. Knowing the conductivity of the earth's crust, and assuming a certain uniform initial temperature, what time must elapse before it cools to such an extent that the temperature-gradient over a certain thickness is that which we find to obtain now? The mathematical expression of this has been solved by Kelvin, who arrives at the result that the whole period since the earth was molten amounts to about twenty million years, and certainly could not exceed four hundred million years.

Another method of his depends upon the braking action which the tides exert upon the rotation of the earth. Since the earth rotates more quickly than the tidal bulge, it follows that the frictional effect thus brought into play must have slowly diminished the period of the earth's revolution. As a time-keeper, in fact, the earth loses some twenty-two seconds in each century, and though this appears a negligible quantity it nevertheless mounts to appreciable proportions when extended over millions of years. Consider, then, for a moment, what this retardation implies. We all know that the earth is not a perfect sphere, but oblately spheroidal, having, in fact, almost exactly the shape it would assume if it were all molten and revolving at its present rate. If the earth, however, had been rotating very much faster when in the liquid condition, and solidification had then taken place, the shape would differ considerably from what we find it to be now. Even if it had been rotating three per cent. faster, the difference would be quite noticeable; for a greater polar flattening would result and the disposition of the oceans could not be as at present; and since mathematical reasoning demonstrates that one hundred million years ago a three per cent. increase in the rotation would obtain, the deduction is drawn that any greater antiquity than one hundred million years can only be regarded as improbable.

The remaining argument is drawn from a consideration of the origin of solar heat and its dissipation by radiation, and led to the conclusion that the sun has illuminated the earth only during a period which is probably less than even one hundred million years and certainly not much more.

This computation, however, and to some extent the second, are based upon data which are necessarily vague and indeterminate, and in consequence much reliance cannot be placed upon the results. As will be shown presently, even the first of the Kelvin estimates has to be rejected on the score of recent discovery; so now there is not one of his methods of estimation to which exception cannot be taken.

In their day, nevertheless, they served a useful purpose; for by awakening geologists from their dream of an unlimited credit on the bank of eternity, and compelling their reluctant limitation to a less exorbitant draft, the above intrusion on the part of physics at least prepared the way for fresh lines of argument of less doubtful validity. Naturally, Kelvin's estimates were at first indignantly discredited, though without any apparent effect upon the firmness of Kelvin's attitude. In vain his opponents appealed to their ancient traditions—geologists to their succession of strata, and palaeontologists to their evolution of types, both of which were believed to require an aeon of time—he simply ignored all with disarming unconcern.

But though the most eminent of the physicists thus arbitrarily defined his isolated position, there were others in his own sphere of activity who refused to recognise the finality of his results, and were disposed rather to compromise with geologists on the question. Thus, Sir G. Darwin, in a review of the three theories, pointed out some of the uncertainties which surrounded them; whilst Professor Perry, in his inimitable style, advanced cogent reasons for believing that the Kelvin computation erred considerably on the side of underestimation. Indeed, Perry was quite willing to concede an estimate four times greater than the greatest of Kelvin's.

These more reasonable views now stand fully justified in the light of more recent knowledge. The first and, as we have mentioned, the most trustworthy of Kelvin's arguments was vitiated during the last few years of the nineteenth century by the discovery of radioactivity and its allied phenomena. This is a point, however, which has to be deferred to a later stage. It is evident that some other methods of attacking the problem were urgent, and as such have happily been forthcoming we shall proceed to discuss them.

II.—SOLVENT DENUDATION.

From a consideration of the weathering forces which on every hand mould the features of continents, Professor Joly derives a method for determining the age of the earth since the time when the latter attained its *consistentior status*.

XUM

Looking for a ready means of computing the total effect produced by the multifarious denudation agencies, he naturally turned to rivers, as being the vehicles for the removal of detritus, and exercised himself to find some constituent which, while capable of sufficiently accurate measurement, should be non-cyclic in character, that is to say, should accumulate in the sea without possibility of return. The well-known fact that the sea, and inland lakes in particular, are slowly growing salter and salter led Joly to select sodium—in the combined state, of course—as the element best satisfying the necessary conditions. The broad outline of the method is now easy to understand. The volume of the ocean has first to be estimated and then, from a knowledge of its average chemical composition, the total quantity of sodium at present in it can be obtained. This sodium must have accumulated there ever since denudation began, and if, therefore, we divide its total by the calculated amount of it which enters the ocean annually from the rivers, an uncorrected estimate of the earth's age will result.

The amount of sodium in the sea at present is known to within a few per cent., but the quantity discharged per annum by all the rivers in the world is not so well authenticated, being much more difficult to determine. The sodium content of rivers is so variable a quantity that the water of a large number must be analysed before any reliable data become available; a difficulty, of course, which time will entirely remove. The magnitude of the quantities in question will be realised from the statement that if all the salt at present in the ocean were consolidated into a uniform layer of rock salt upon the land area of the globe the earth would be covered to a depth of about four hundred feet.

Without going into numerical details the fact may be stated that the estimate of the earth's age derived from the above-mentioned data amounts to practically one hundred million years.

To this number several corrections must be applied. The most important of these refers to what is known as "wind-borne sodium," *i.e.*, to those impalpable particles of salt which are carried inland by air currents. This factor slightly disturbs the non-cyclical character of the process, but only requires a small correction (six to ten per cent.). Relatively insignificant, too, is a correction which takes into account the land deposits of sea-salts. The only other conceivable corrections are inherent in the method itself, or, more precisely, in the assumptions which lie at the basis of the method. There is, for instance, the possibility that in the remote past the conditions which determined the rate of denudation were far different from those which prevail to-day. The sun may have been much less powerful, or, on the other hand, the elements may have been more active, and therefore more destructive. Again, there is every reason to believe that the ratio of land to sea has been far from constant during the long ages of the past. But if uniformity of the past and present conditions be assumed, as indeed seems most likely, and the other uncertainties be duly allowed for, the time which has elapsed since the "waters under the heavens were gathered together in one place, and the dry land appeared," runs to between eighty and ninety million years.

A couple of years ago the fundamental assumption underlying Joly's method was challenged by Dr. Becker, who put forward some very interesting views. He pointed out that the sodium of the ocean is derived mainly from igneous rocks, and that when denudation began these rocks were the sole constituents of the earth's crust. A very different state of affairs obtains nowadays. Sedimentary rocks are the obvious features of surface strata, and the igneous rock lies buried far beneath them. Does not this imply that the rate of decomposition has changed considerably since the early days of the earth's youth? For, whereas the necessary rocks were then freely exposed to denudation influences, the upper layer of decomposition products now arrests decay. In other words, the rate of decomposition, being dependent upon the area of exposure, has diminished throughout the ages in the same way as a sum of money would diminish if subjected to a certain percentage deduction annually, each deduction being calculated on the sum still remaining at the beginning of the year. That is to say, it has varied according to an exponential law. The estimate of the earth's age, worked out on this formula, gives a somewhat smaller value than by Joly's method, *viz.*, from fifty to seventy million years.

However, the two results are of the same order of magnitude, preference perhaps being given at present to Joly's value. Let us see if this is borne out by the next computation.

III.—STRATIGRAPHY.

The reverse of the preceding method would obviously consist in determining the rate at which the strata are being deposited; and then, from a knowledge of the maximum depth of the stratified rocks, an estimate of the earth's age readily follows. Sir A. Geikie, even before Lord Kelvin had assaulted the geological stronghold, held that one hundred million years would suffice for the history of the sedimentary rocks. More recently Professor Sollas, Professor Joly and others have discussed the question.

The uncertainties attached to the method, however, render it practically impossible to obtain any reliable result. From the observations of geologists in different parts the maximum thickness of the deposits laid down during the various geological epochs has been estimated, but the accuracy of the measurements decreases with the increasing antiquity of the formation concerned, until, when pre-Cambrian times are reached, anything but the merest guesswork becomes impossible. Even were this difficulty removed, the intermediate lapses of time which are represented by unconformities and

other appearances must, of necessity, be disregarded.

When it comes to measurements of the rate of accumulation of the various strata, still greater difficulties are encountered. Theoretically, it is only necessary to measure the annual silt-loads of various rivers, as well as the catchment area, and the rate of deposition ensues. But, in practice, the rates are found to be so divergent and variable that the average counts for little. As Joly points out, we are at liberty to assume anything from a foot to a few inches deposition per century. Taking the rate of accumulation to be four inches in the century, the age of the sedimentary column, which is between sixty and seventy miles thick by the best estimate, then works out to be about one hundred million years. Sollas gets thirty millions; Joly gets eighty million years. The latter is probably the more likely of the two, so we shall not be far wrong if we consider our one hundred-million year computation as fairly near the mark.

IV.—RADIOACTIVITY.

Among the many wonderful possibilities which radioactivity has to offer, the determination by its aid of the age of the earth may be the least important; but it is undoubtedly one of the most interesting, opening up as it does such a splendid field for discussion and speculation.

In the first place, it deals the death-blow to Kelvin's thermodynamic method. The disintegration of a radioactive body is known to be accompanied by a spontaneous evolution of heat energy, and, considering the widespread character of these bodies throughout the earth's crust, the total heat developed in this way can be no negligible quantity. Indeed, so far as present estimates go, it *more* than accounts for the earth's annual loss by radiation—truly an embarrassing position for the earth, as will be shown in a moment. The supposition, then, that the earth is merely a cooling body, whose primitive stock of heat is being slowly depleted, must be modified in order to take account of the new factor. Let us examine afresh our conception of the life-history of the earth.

The fact that the molten earth contains a considerable store of long-lived radioactive elements would not appreciably retard its cooling until the *consistentior status* was reached. Then, on the formation of the surface crust, the rate of cooling would be reduced to a very small fraction of its former value; comparable, in fact, with the heat liberated during elemental disintegration. Near the surface of the earth this heat is sufficient, we have seen, to make good the radiation loss; whereas in the interior, where escape is impossible, the heat generated cannot but have accumulated during the long geological epochs. The final result is evident. Not from without, by collision with some wandering star, but from within, by her own irrepressible vulcanicity, is the destruction to come which is to return the earth to her pristine state, to begin again her life-history, perhaps for the *n*th time, where *n* represents an unknown quantity. In a similar way the long duration of the sun's heat is accounted for, and another theory of Kelvin's exploded.

But let us get back to age determination. The basis of the radioactivity method will be clearly understood if it be remembered that radium is an element whose parentage is known and whose descendants to many generations have been fairly definitely established. In other words, this singular element has been proved to be one of a series which begins with uranium and proceeds down a scale of radio-elements of diminishing atomic weight until the final stable substance, now thought to be lead, is reached. The disintegrating process is accompanied at almost every stage by a loss of what are called α particles, which themselves have recently been shown to be identical with helium atoms.

Of course, the process of degradation is inconceivably slow, though the time-rate for each stage has actually been calculated from laboratory observations. The number of helium atoms discarded during each of the transformations is likewise known. Assuming, then, that all these discharged atoms have accumulated *in situ* in any geological formation, it is only necessary to determine in a specimen mineral the ratio of the occluded helium to the still-remaining radioactive element in order to arrive at an estimate of the age of the strata from which the mineral was taken.

The Hon. R. J. Strutt, in particular, has examined from this point of view many minerals taken from strata of the different geological epochs. His results are too numerous to quote, but so far they have not been particularly satisfactory. Even in material obviously contemporaneous, for instance, the variations in the geological ages turn out to be very considerable. The weak point of the whole method seems to lie, not in the theoretical assumptions involved, but rather in the improbability of a complete helium accumulation. It appears likely that the varying experiences to which the helium-bearing formations have been subjected throughout their existence—such as changes of temperature and pressure or the solvent action of percolating waters—have all contributed to an appreciable alteration in the amount of helium accumulated. The advantage that the method otherwise possesses, in that each determination is an independent estimate of the geological age, is thus swamped by the disability just referred to, and any results which are the outcome of such a method must consequently be received with caution.

The problem has recently been approached from another standpoint, and, at first sight, one more reliable. If lead is really the ultimate product of the disintegration of uranium—and much evidence has been adduced in support of this view—then from the uranium-lead ratio supplementary estimates are possible. Professor Boltwood has attacked the problem of the age of the earth from this assumption, and is led thereby to attribute to a number of uranium-bearing minerals an age which ranges from

two hundred to one thousand three hundred million years; though since the geological positions of the rocks examined are not available the figures do not convey much.

Considered broadly, the evidence of radioactivity is to assign to the earth an age considerably greater than results from any other method. This either means that the accuracy and, perhaps, the fundamental assumptions, of the other methods are impugned, or that the radioactivity method itself is founded upon hyphotheses which are not justifiable. There is even some reason for believing that the latter is not altogether out of question. Thus, though no acceleration in the rate of disintegration of uranium has yet been observed in the laboratory, it is not beyond the pale of possibility that some conditions did prevail in the earlier stages of the earth's history which are not experimentally realisable to-day, but which then determined an increase in the rate of decay. It would be unwise, however, to pursue speculation further, notwithstanding an innate desire to cast doubt upon a method which, by disturbing the gradual maturing and stabilisation of our views before its appearance, has thrown us back into what Professor Schuster describes as "the primitive state where no opinion is absurd and every hypothesis justifiable." Until further evidence of a more convincing nature is forthcoming, we may provisionally assign an age of not less than one hundred million years to this earth of ours.

Of course, this estimate takes us back only to the *consistentior status*. Whether, before that, the sun was still pouring his beneficent rays upon the earth, so that the present estimate of the earth's age is not merely an estimate of the sun's activity, or whether, instead, after solidification of the outer crust, the earth rolled through space as a dead world shrouded in darkness save "where her volcanoes glowed red in the eternal night," cannot be answered decisively. From present evidence it appears very likely that the sun shone brightly long before the earth came into existence, and the one hundred million years would not then have to be very materially increased in order to take us back to the very birth of the earth. On the other hand, it may be that the discrepancies between the results derived from a consideration of denudation and of radioactivity are to be interpreted as pointing to long aeons of time during which the earth slept as she rolled through space.

It would be an interesting diversion to consider whether the whole scheme of evolution outlined by Darwin and others could possibly be worked out within such a comparatively short period as we have accepted. Are one hundred million years time enough for that evolution of the organisms which, starting with a shapeless mass of protoplasm, determined its development through countless structures of increasing complexity, until finally man himself was reached? At this stage only the briefest of answers can be given. Eminent biologists declare that the period *is* ample and the ordinary doubts of the layman may therefore be laid aside.

The period of one hundred million years, then, which have been conceded to the earth, is from most points of view a reasonable estimate. It cannot be expected, however, that finality is attained. This estimate, like its predecessors, may have to be discarded if further investigation requires it, though as yet there seems no valid reason for abandoning it. Nevertheless, our ideas on the subject must be pliant and versatile, our minds ready to recognise the meaning of revolutionary discovery. The best attitude, perhaps, is that which regards the one hundred million years as the earth's *minimum* age, and is prepared, if occasion demands, to consider impartially an estimate of greater—it may be much greater—magnitude.

CORRESPONDENCE.

SPURIOUS DIAMETERS OF STARS.

To the Editors of "KNOWLEDGE."

SIRS,—Reading recently the papers of Sir W. Herschel, published last year by the Royal and Royal Astronomical Societies, I was surprised to see his statement that increase of magnifying power with the same aperture of object glass or mirror causes a decrease in the size of the spurious discs of stars. I was fully under the impression from reading modern works that the reverse was the case. I know that increase of aperture means decrease of diameter of spurious discs, but the other was news to me. Herschel's words are: "By many observations their spurious diameters are lessened by increasing the power, and increase when the power is lowered." In Vol. II., page 303, again he says that the diameter of spurious disc of α Aurigae with power 227 was 2″·5, and that of α Tauri with power 460 was 1″ 46‴, and with 932 it was 1″ 12‴, while that of α Lyrae with power 6450 was 0″·3553. I should be glad if some of your astronomical readers would reconcile these extracts with present-day ideas.

THEODORE B. BLATHWAYT.

CAPE TOWN.

STELLAR DISTANCE UNITS.

To the Editors of "KNOWLEDGE."

SIRS,—I notice some comments in your July issue regarding names for the planetary and stellar distance units. In my opinion the names suggested are quite impossible—ugly of look and ugly of speech. The names for any unit of measure should assuredly be short and easy to pronounce. Dr. Crommelin's suggestion of "astron" for one is quite acceptable. But why bother about the inner significance of the words at all? An arbitrary adoption would do quite as well. Why not follow the course adopted in electrical measurements? Here we have "Watts" and "Amperes"; in Astronomy we might well have "Keplers" and "Newtons." Let the former stand for the shorter or earth-sun unit, and the latter for the longer "light-year." In order to destroy the personal look about the terms they might well be abbreviated to "keps" and "newts." As alternatives the names of the men who (*a*) first determined the earth-sun distance and (*b*) who first used the "light-year" of a unit of measure might be used.

A. J. H.

ABERYSTWYTH.

A PLEA FOR A BRITISH FOLK-MUSEUM.

By W. RUSKIN BUTTERFIELD.

A PROPOSAL has recently been made to utilise the Crystal Palace and grounds for a National Folk-Museum on the lines of the famous Nordiska Museet at Stockholm, with its open-air department of Skansen.

The last two decades have witnessed the formation of folk-museums in various parts of Europe, and especially in the Scandinavian countries. In addition to the one mentioned at Stockholm, Sweden possesses others at Lund, and at Bunge in the island of Gotland; in Norway similar institutions have been established at Christiania, Lillehammer, Elverum, and Hamar; and in Denmark at Copenhagen. Their *raison d'être* is to illustrate in a concrete manner the evolution of national culture and characteristics; to trace the modes of life of the people in times past and to preserve representative examples of national buildings, domestic and other appliances, costumes, personal ornaments—in short, to bring together in one locality all such objects as best serve to reconstruct the conditions of life in their respective countries from remotest times.

In no country is a national folk-museum so necessary as in England, because in no other country is there such a dearth of distinctively national objects, and also because no other country has outgrown its past so rapidly and so completely in regard to indigenous customs, amusements, and modes of life generally. What an unalluring sight is presented, for instance, by the interiors of the smaller homes of the land at the present time. The furniture, pottery, and other objects are almost all of the factory type. Here and there, it is true, one does find an old corner cupboard, a lace christening cap, or a piece of slip-ware made at some forgotten local pottery and containing perhaps a presentation inscription commemorating a wedding or a betrothal; but these old folk-objects are few and far between. During the Victorian period especially there existed a profound apathy, if not antipathy, for what was deemed old-fashioned. Mural paintings were hidden behind coats of lime-wash, oak-panelling was torn from the walls, and immemorial seasonal customs in town and village alike dwindled to their final abandonment. No less striking were the changes wrought by the concentration of industries and by increased facilities for transport. Home industries, such as weaving and lace-making, and local crafts, like those of the potter and the basket-maker, were diverted from the villages to factories in the larger centres of population. A national folk-museum would take account of these several changes and preserve the links between the past and the present.

The British Museum at Bloomsbury and the Victoria and Albert Museum at South Kensington are national in scarcely any other sense than that they are State institutions. The splendid collections in the former tell us as much, if not indeed more, about the ancient Egyptians and Greeks than about our own peoples and our own land. The equally fine collections at South Kensington have been accumulated mainly for the special purpose of providing objects, irrespective of their place of origin, to serve as standards in the industrial and fine arts. Moreover, the methods of exhibition in these great museums are only partly in keeping with the spirit of folk-museums. Instead of displaying collections in formal series in standardised glass cases, the folk-museums assemble their objects so far as possible in related groups. But the great failing of the museums in question lies in their remoteness from the realities of every-day life. They restrict themselves too rigidly to things which are merely rare or precious, or which attain a certain artistic merit. They pay little or no concern to the ordinary man and woman. In other words, they touch the circle of national life only at the glowing centre instead of reaching to the wide periphery.

Now let us turn to the proposed scheme and see, so far as is possible in a bare outline, what it is intended to accomplish. Taking the Crystal Palace grounds first, it is proposed to establish therein an open-air museum. Of all the survivals from former times, none surpass in interest the people's homes. The first duty, therefore, of the open-air museum would be to secure ancient houses bearing in a sufficiently well-marked manner features distinctive of some period or locality. The buildings would be taken down and re-erected in the grounds with scrupulous regard to their original form. It is not contemplated, it need hardly be said, to ransack the English countryside and tear buildings from their time-honoured sites, where there is no danger of their demolition or serious mutilation, but to rescue here and there worthy and typical buildings in imminent danger of destruction. After their re-erection the houses will be provided with contemporary furniture and all appropriate appliances, the idea being to show them exactly as they appeared to the people of the time. Some of the houses might have associated with them old English gardens, with a columbarium, a well-house, a sundial, and clipped yews. Consider how fascinating such sights would be, not only to ourselves, but also to visitors from amongst our kinsmen in the dominions beyond the seas.

In some cases, instead of removing whole houses,

XUM

it would be sufficient to secure the ceiling, a fireplace, a panelled room, or the main staircase, and to instal these in rooms in the Crystal Palace.

Besides domestic buildings, other structures would be treated in the same way, such as ancient barns and water-mills. It might even be possible to save some abandoned and decaying English church whose preservation is demanded by its age or importance. Such a church would form the most appropriate home for the display of ecclesiastical art. No doubt many people would find it hard to assent to the removal of a church from its parish, but such removal and preservation are better than decay and final ruin.

The scheme provides for the assignment of a portion of the grounds for our great national games and pastimes; here would be a maypole for the children and a bowling green for their elders. A dancing floor would be laid out for national dances, and an open-air theatre prepared for the performance of historical pageants and stage plays. At Skansen, spacious enclosures are reserved for living examples of Swedish mammals and birds. This might be imitated by a miniature British "Zoo."

As to the Crystal Palace itself, it would serve for the exhibition of objects of all sorts illustrating the daily life, occupations, and amusements of the peoples of these islands. One room could be devoted to children's toys, another to objects used by women in indoor amusements, another to the apparatus and methods of producing fire in past times (a most seductive subject), another to inventions, another to models to enable the blind to gain, by tactual means, a knowledge of some of the more interesting objects in the various departments. Space would further be required for developmental series of English metal-work, wood-carving, pottery, glass, furniture, and textiles; also for such things as hand-looms, vehicles, old surgical instruments, inn-signs, the regalia of guilds and other societies, stocks, gibbets, clocks, tallies, charms, cheese-presses, and a multitude of others. Special stress would be laid upon objects typified by ornamental lace-bobbins, carved bone apple-scoops, and costumes, as it is just such things as these that best illustrate the trend of native culture.

The framers of the scheme point out that it would be particularly appropriate if a number of rooms in the Crystal Palace could be devoted to collections relating to past and present members of our Royal house, such as portraits, ceremonial robes, and personal relics. The present writer had hopes at one time that Stafford House might be converted into a royal museum after the fashion of Rosenborg Castle at Copenhagen, but the future of that building has been settled otherwise.

A national folk-museum like this would illustrate, by means of actual objects, historical continuity. After all, the present can only be measured in terms of the past, and, unhappily, in England our past is rapidly disappearing beyond recall. If the project is delayed much longer its effectual accomplishment will become impossible. Other European countries are fully alive to the importance of preserving unbroken the records of national life. There is little in our past to be ashamed of; there is much of which we may justly be proud.

Through the patriotic action of Lord Plymouth, Sir David Burnett, and of *The Times*, the Crystal Palace grounds are now available for some public purpose. It is desirable, from every point of view, to take advantage of so unique an opportunity for promoting the establishment of a permanent and comprehensive national folk-museum. The central feature of the situation lies in the fact that, if these grounds are assigned to some other use, no other open stretch of land so near London of such magnitude can ever again be forthcoming. It is a duty we owe to posterity no less than to our forbears, to preserve, while it is still possible, the fast dissolving links that bind us with the past.

I wish to express my indebtedness to Mr. Bernhard Olsen, of the Dansk Folkemuseum, Mr. Hans Aall, of the Norsk Folkemuseum, Mr. Bernhard Solen, of the Nordiska Museet, and Dr. Anders Sandvig, founder of Maihaugen Open-air Museum, for kind permission to reproduce the accompanying illustrations; also to Dr. F. A. Bather and Professor Henri Logeman for valued assistance.

THE ARTIFICIAL RIPENING OF FRUITS.

The Gardeners' Chronicle for July 19th points out that the Arabs have for centuries ripened dates artificially by exposing them to the fumes of vinegar; and refers to the ripening of persimmons by the Japanese, who store them in a closed cask in which the national alcoholic beverage known as saké has been kept. Professor Francis Lloyd's method of exposing unripe fruits under a pressure (of from fifteen to forty-five pounds to the square inch) to the action of carbon dioxide for fifteen to thirty-six hours is also discussed. What happens in the process is not altogether clear, but we quote the following remarks:—

"Astringency is due to the action on the tongue of the tannins contained in the unripe fruit. It disappears if the tannins are destroyed, or if these bitter substances are prevented from acting on the tongue. Carbon dioxide seems to produce the latter effect, and in the following way: Associated with the tannins in plant tissues are coagulable substances. Such substances when caused to coagulate hold the tannins very strongly, so strongly, indeed, that the latter substances are prevented from giving rise to an astringent taste when the fruit containing them is eaten. In short, the coagulated substance plays the part of the coat of a bitter pill, enabling the latter to be taken untasted. The explanation may be that which has been given; but we are inclined to think that other changes are induced by carbon dioxide. For example, it is possible that the effect of carbon dioxide is to hasten the oxidation processes of the tissues, and hence to cause a partial or complete destruction of the astringent substances. Whatever be the precise interpretation of the process the important thing is to ascertain whether a similar process may be induced in our common large fruits; for although artificial ripening is primarily of importance to the grower of tropical fruits—dates, bananas, persimmons, and the like—it may prove also of service to the home grower."

the properties of spirit more clearly than heretofore, and we call the matter "living" because we recognise the kinship between its spirit and that which we call "ourselves." The *raison d'être* and purpose of the whole process is, I believe, the differentiation of homogeneous spirit into individual, self-conscious units or souls capable of true happiness—the one thing of absolute value. This is only perfectly achieved in man. Of course, a theory so wide and comprehensive as this deserves more than the bald statement here alone possible. I have attempted a fuller statement, though very inadequately, in the essay already referred to; and I must also refer the reader to the remarkable metaphysical treatise of the Swedish philosopher, Swedenborg, entitled "The Divine Love and Wisdom," which is the chief source of these views concerning the ultimate significance and nature of life. My primary reason for calling attention to the theory here is to indicate how entirely it fits in with the doctrine of evolution and the latest scientific view concerning the possibility of the spontaneous generation of life.

CORRESPONDENCE.

THE NUMBER OF "DOUBLE" STARS.

To the Editors of "KNOWLEDGE."

SIRS,—In your number for June, on page 239, Mr. E. Holmes criticises a correct statement of the late Mr. F. W. Henkel as to the number of known double stars. The words he quotes are: "Perhaps as many as twelve thousand such couples are known." I take exception to his criticism; the most correct word of these ten is *perhaps*. Further, the expression "standard authority" is out of place; there is no *one* standard authority. Let me explain. The branch of astronomy known as "double stars" (two stars in close juxtaposition as viewed from the earth) has become very expansive since I commenced observing double stars in 1881; the great increase in the optical power of recent telescopes has brought thousands of optical pairs of stars upon record. The chief merit of these modern observations is that they are made with the finest instruments and most skilled observers in this branch; many of these observations are duly recorded in Mr. Burnham's "Magnum Opus," in 1170 pages, and the total number of double stars which he gives therein is thirteen thousand six hundred and sixty-five (not fifty-five, as given by Mr. Holmes). This work was published in 1906 by the Carnegie Institution of Washington.

But of what does this consist? I opened this catalogue at random and it happened to be page 112; this is what is there (with thirty-three properly observed pairs):—

No.	Position Angle.	Distance.	Magnitudes.	Year.
5564	116°·3	15″±	8–9, 11	1830+
5568	331 ·8	7 ±	11 = 11	1834·3
5575	305 ±	20 ±	6 17–18	1820+
5577	70 ±	2 ±	13 14	1820+
	305 ±	25 ±	15	1820+
5578	53 ·8	4 ±	10–11, 11–12	1830+
5587	69 ·4	25 ±	9–10, 10	1830+
5588	...	...	9 ...	...
5589	35 ±	12 ±	11 12	1828+
5593	210 ±	135 ±	5 ...	1873·29
	130 ±	5 ±	9·0 10·0	1873·29
5596	...	Cl. IV	8 11	...
5601	22 ·5	15 ±	10–11, 14	1830+
	208 ·0	18 ±	14	1830+
5602	...	Cl. IV	8–9 10	...
5607	...	Cl. IV	8 11	...
5609	130 ±	15 ±	9 10	1820+
5610	...	33 ·27	... ...	1783·09
5611	...	...	9·1 ...	1902·
5612	139 ·0	15 ±	9–10, 11	1830+

Upon referring to Vol. II (notes) I find there is no further information given to Nos. 5568, 5577, 5578, 5596, 5602, 5612; to Nos. 5564, 5575, 5587, 5593, 5611 there are recent and accurate measures given; therefore the Herschel approximations might have been abandoned and not again reprinted. They are already in Smyth's "Celestial Cycle" and Gledhill's "Handbook"; Nos. 5588, 5589, 5601, 5607, 5609, and 5610 have notes, and there seems no need to have again numbered them, nor to have included them in a good reference catalogue, except among the notes or in a table in the Introduction.

The general result is that on page 112 there are fifty pairs of stars: of these, seventeen are as just quoted in detail, none of which should have so appeared in an accurate and up-to-date catalogue, except as mere notes. The whole volume is similar to this, and the 13,665 pairs or double stars may be safely reduced by at least twenty-five per centum, and we get about nine thousand pairs worthy of inclusion in the tabular catalogue: the R.A.'s and Declinations are given for an old epoch (1880). Then this only includes stars to minus thirty-one degrees; none of Innes's valuable work, or of other southern observers, is included. So Mr. Henkel's "*perhaps* as many as twelve thousand such couples are known" is a statement not very far from the correct number at present published, mere estimations omitted. From Mr. Holmes's reference to other catalogues of double stars one is lead to believe that he is unacquainted with the contents of that excellent catalogue by Mr. T. Lewis, published also in 1906. While the catalogue of Mr. Burnham is collected from all or many sources since 1780, and is still far from complete or homogeneous in character—though a work of reference so far as it goes—that by Mr. Lewis is formed upon a definition plan, being based upon a systematic series of observations of about three thousand double stars by W. Struve, with which have been incorporated in detail all known and good observations until about 1904. Much valuable information upon the orbits of the more interesting *binary* stars is given—as also in Mr. Burnham's catalogue. So it may be truly called a standard work of reference for W. Struve's stars, and it will be used for many a year; it does not touch those modern pairs of bright stars with very faint stars within about 1″, observed with instruments of 25-in. to 40-in. object glasses. So much for the visual pairs, few of which are "binaries."

What of the spectroscopic binaries, which are of the greatest interest? Their known number is already considerable. None of these are as yet thought to be worthy of inclusion in a so-called *standard* catalogue of "double stars." Mere numbers will not make a standard catalogue; uniform quality, completeness, and up-to-date epoch and material is what we should expect.

OXFORD. F. A. BELLAMY.

P.S.—I should like to mention that this letter was written quite in ignorance of Mr. Henkel's death, and it was in type before I was informed of it.

XUM

THE AGE OF THE EARTH.

By E. JOBLING, A.R.C.Sc., B.Sc., F.C.S.

THE discovery of the embalmed corpse of one of Egypt's ancient kings or the unearthing of some hieroglyphic inscription apparently dating back to Biblical times, are items of information which, when they reach the public ear, awaken at least a transient interest in the probable antiquity of the one or the bearing of the other upon the history of the peoples of the world. The call of the past is an appeal to which few of us are really irresponsive, though in most the receptive faculty gets dulled by inactivity, due in large measure to the lack of that divination which sees interest in objects of almost everyday acquaintance.

To comparatively few, for instance, has it ever occurred that in the age and life-history of that world upon which they "live and move and have their being" is to be found a problem of keener and more lasting interest than either of the above. The indifference of the many to this question cannot nowadays be attributed to a prevalent unquestioning belief in the Scriptural computation which ascribed to the earth a longevity of between six and seven thousand years; for this form of mental paralysis is happily now a thing of the past. It can only be the absence of any acquaintance with the general trend of scientific thought which debars them from the very real pleasure to be derived from the story of man's endeavours to delve into the unknown.

After all, to determine the age of the earth is a far more difficult undertaking than to assign the mummified king to his position in the Egyptian dynasties or to unravel the hieroglyphics of a Babylonian column. The presence of a coin or inscription in the one or a scientific deciphering of the other solves the respective problems; but in the case of the earth the difficulties encountered are not so easily overcome. The shape of the earth has to be determined, its strata have to be laid bare, its oceans weighed, and a thousand and one other investigations satisfactorily completed before even the data are amassed by means of which we hope to realise the vast stretches of time that preceded the very earliest of historians. Stupendous as the obstacles are, however, sufficient is known already to fling into the misty past a beam of light powerful enough to reveal with tolerable certainty the features of the earth as they presented themselves, say, a hundred million years ago, and to dispel to some extent the darkness of an even greater antiquity, if we call to our aid a little justifiable hypothesis.

Already it has been hinted that only in quite recent times has the question been approached scientifically. Time was when "catastrophism" was the current idea, and men believed that the earth, and indeed the whole solar system, had suddenly sprung full-fledged into being at some ridiculously recent date. When, however, the foundations of geology came to be laid by Hutton and Lyell, the immensity of the time required for an orderly deposition of the sedimentary rocks or the elaboration of the organic world laid such hold upon their imagination that "catastrophism" was abandoned for the other extreme, "utilitarianism," which relegated the birth of the earth to the very beginning of time and refused to adopt any smaller chronological standard than an "eternity."

These somewhat ludicrous extremes are now, of course, replaced by more reasonable views, which owe their conception to the application of the modern scientific spirit and the ever-growing accumulation of experimental data. The iconoclast who assailed and overturned the above extravagant hypothesis was Lord Kelvin, then Sir W. Thomson, who, in the few years following 1862, published papers in which he proceeded by several physical lines of reasoning to an estimate of the earth's age so small comparatively as to make the then-orthodox geologists gasp with surprise and indignation. These estimates of his—historically interesting, if now perhaps obsolete—will be briefly dealt with first before attention is turned to other more reliable evidences advanced in recent years.

It would be as well, however, before discussing the theories if we first obtain a clear idea of the various phases of life-history through which the earth has passed in order that no confusion may subsequently arise as to the relative significance of the numerical values obtained.

Imagine, then, a vast molten globe—the product, we may take it, of the condensation of a nebular haze—rapidly rotating round the sun. The influence of the latter would be such as to develop vast tides in the liquid magma of the rotating body, one of which tidal waves, the late Sir G. Darwin suggested, might conceivably have assumed sufficiently large proportions as to disturb the stability of the whole, and to be itself trundled off into space, where it would continue to revolve around the remainder as the infant moon. Sir G. Darwin, by-the-by, has calculated the time which has elapsed since this separation to be fifty-six million years. Its birth-pangs over, what we now know as the "earth" starts upon its career as a separate member of the solar system. Probably soon after the moon's departure the earth had cooled enough to permit of the formation on the sea of magma of floating islands of scoria, which would assume larger and larger dimensions until the outer crust of the earth was entirely solid and what is called in the earth's history its *consistentior status* was inaugurated. Further cooling resulted in the condensation of some of the constituents of the atmosphere, which products would collect in

pockets on the surface, and thus the configuration of continents and oceans arose. Sooner or later, yet another era would be ushered in by the commencement of those processes of denudation and deposition which, throughout the long ages following, have reared new continents upon the ruins of the old, and which still manifest their slow-moving but irresistible activities before our eyes. At what period signs of life appeared and the earth first became inhabited we cannot stay to discuss, but must revert to our original theme.

I.—KELVIN'S THEORIES.

During mine-sinking operations it is noticeable that as the shaft penetrates deeper and deeper the temperature slowly and regularly increases. In different places the temperature-gradient is not the same; for external conditions necessarily disturb it in the topmost strata, and we have not yet delved deep enough to reach the lower regions where uniformity prevails. But from observations made an average can be taken, and from this it is possible to deduce mathematically an estimate of the earth's age. The problem resolves itself into the following. Knowing the conductivity of the earth's crust, and assuming a certain uniform initial temperature, what time must elapse before it cools to such an extent that the temperature-gradient over a certain thickness is that which we find to obtain now? The mathematical expression of this has been solved by Kelvin, who arrives at the result that the whole period since the earth was molten amounts to about twenty million years, and certainly could not exceed four hundred million years.

Another method of his depends upon the braking action which the tides exert upon the rotation of the earth. Since the earth rotates more quickly than the tidal bulge, it follows that the frictional effect thus brought into play must have slowly diminished the period of the earth's revolution. As a time-keeper, in fact, the earth loses some twenty-two seconds in each century, and though this appears a negligible quantity it nevertheless mounts to appreciable proportions when extended over millions of years. Consider, then, for a moment, what this retardation implies. We all know that the earth is not a perfect sphere, but oblately spheroidal, having, in fact, almost exactly the shape it would assume if it were all molten and revolving at its present rate. If the earth, however, had been rotating very much faster when in the liquid condition, and solidification had then taken place, the shape would differ considerably from what we find it to be now. Even if it had been rotating three per cent. faster, the difference would be quite noticeable; for a greater polar flattening would result and the disposition of the oceans could not be as at present; and since mathematical reasoning demonstrates that one hundred million years ago a three per cent. increase in the rotation would obtain, the deduction is drawn that any greater antiquity than one hundred million years can only be regarded as improbable.

The remaining argument is drawn from a consideration of the origin of solar heat and its dissipation by radiation, and led to the conclusion that the sun has illuminated the earth only during a period which is probably less than even one hundred million years and certainly not much more.

This computation, however, and to some extent the second, are based upon data which are necessarily vague and indeterminate, and in consequence much reliance cannot be placed upon the results. As will be shown presently, even the first of the Kelvin estimates has to be rejected on the score of recent discovery; so now there is not one of his methods of estimation to which exception cannot be taken.

In their day, nevertheless, they served a useful purpose; for by awakening geologists from their dream of an unlimited credit on the bank of eternity, and compelling their reluctant limitation to a less exorbitant draft, the above intrusion on the part of physics at least prepared the way for fresh lines of argument of less doubtful validity. Naturally, Kelvin's estimates were at first indignantly discredited, though without any apparent effect upon the firmness of Kelvin's attitude. In vain his opponents appealed to their ancient traditions—geologists to their succession of strata, and palaeontologists to their evolution of types, both of which were believed to require an aeon of time—he simply ignored all with disarming unconcern.

But though the most eminent of the physicists thus arbitrarily defined his isolated position, there were others in his own sphere of activity who refused to recognise the finality of his results, and were disposed rather to compromise with geologists on the question. Thus, Sir G. Darwin, in a review of the three theories, pointed out some of the uncertainties which surrounded them; whilst Professor Perry, in his inimitable style, advanced cogent reasons for believing that the Kelvin computation erred considerably on the side of underestimation. Indeed, Perry was quite willing to concede an estimate four times greater than the greatest of Kelvin's.

These more reasonable views now stand fully justified in the light of more recent knowledge. The first and, as we have mentioned, the most trustworthy of Kelvin's arguments was vitiated during the last few years of the nineteenth century by the discovery of radioactivity and its allied phenomena. This is a point, however, which has to be deferred to a later stage. It is evident that some other methods of attacking the problem were urgent, and as such have happily been forthcoming we shall proceed to discuss them.

II.—SOLVENT DENUDATION.

From a consideration of the weathering forces which on every hand mould the features of continents, Professor Joly derives a method for determining the age of the earth since the time when the latter attained its *consistentior status*.

XUM

Looking for a ready means of computing the total effect produced by the multifarious denudation agencies, he naturally turned to rivers, as being the vehicles for the removal of detritus, and exercised himself to find some constituent which, while capable of sufficiently accurate measurement, should be non-cyclic in character, that is to say, should accumulate in the sea without possibility of return. The well-known fact that the sea, and inland lakes in particular, are slowly growing salter and salter led Joly to select sodium—in the combined state, of course—as the element best satisfying the necessary conditions. The broad outline of the method is now easy to understand. The volume of the ocean has first to be estimated and then, from a knowledge of its average chemical composition, the total quantity of sodium at present in it can be obtained. This sodium must have accumulated there ever since denudation began, and if, therefore, we divide its total by the calculated amount of it which enters the ocean annually from the rivers, an uncorrected estimate of the earth's age will result.

The amount of sodium in the sea at present is known to within a few per cent., but the quantity discharged per annum by all the rivers in the world is not so well authenticated, being much more difficult to determine. The sodium content of rivers is so variable a quantity that the water of a large number must be analysed before any reliable data become available; a difficulty, of course, which time will entirely remove. The magnitude of the quantities in question will be realised from the statement that if all the salt at present in the ocean were consolidated into a uniform layer of rock salt upon the land area of the globe the earth would be covered to a depth of about four hundred feet.

Without going into numerical details the fact may be stated that the estimate of the earth's age derived from the above-mentioned data amounts to practically one hundred million years.

To this number several corrections must be applied. The most important of these refers to what is known as "wind-borne sodium," *i.e.*, to those impalpable particles of salt which are carried inland by air currents. This factor slightly disturbs the non-cyclical character of the process, but only requires a small correction (six to ten per cent.). Relatively insignificant, too, is a correction which takes into account the land deposits of sea-salts. The only other conceivable corrections are inherent in the method itself, or, more precisely, in the assumptions which lie at the basis of the method. There is, for instance, the possibility that in the remote past the conditions which determined the rate of denudation were far different from those which prevail to-day. The sun may have been much less powerful, or, on the other hand, the elements may have been more active, and therefore more destructive. Again, there is every reason to believe that the ratio of land to sea has been far from constant during the long ages of the past. But if uniformity of the past and present conditions be assumed, as indeed seems most likely, and the other uncertainties be duly allowed for, the time which has elapsed since the "waters under the heavens were gathered together in one place, and the dry land appeared," runs to between eighty and ninety million years.

A couple of years ago the fundamental assumption underlying Joly's method was challenged by Dr. Becker, who put forward some very interesting views. He pointed out that the sodium of the ocean is derived mainly from igneous rocks, and that when denudation began these rocks were the sole constituents of the earth's crust. A very different state of affairs obtains nowadays. Sedimentary rocks are the obvious features of surface strata, and the igneous rock lies buried far beneath them. Does not this imply that the rate of decomposition has changed considerably since the early days of the earth's youth? For, whereas the necessary rocks were then freely exposed to denudation influences, the upper layer of decomposition products now arrests decay. In other words, the rate of decomposition, being dependent upon the area of exposure, has diminished throughout the ages in the same way as a sum of money would diminish if subjected to a certain percentage deduction annually, each deduction being calculated on the sum still remaining at the beginning of the year. That is to say, it has varied according to an exponential law. The estimate of the earth's age, worked out on this formula, gives a somewhat smaller value than by Joly's method, *viz.*, from fifty to seventy million years.

However, the two results are of the same order of magnitude, preference perhaps being given at present to Joly's value. Let us see if this is borne out by the next computation.

III.—STRATIGRAPHY.

The reverse of the preceding method would obviously consist in determining the rate at which the strata are being deposited; and then, from a knowledge of the maximum depth of the stratified rocks, an estimate of the earth's age readily follows. Sir A. Geikie, even before Lord Kelvin had assaulted the geological stronghold, held that one hundred million years would suffice for the history of the sedimentary rocks. More recently Professor Sollas, Professor Joly and others have discussed the question.

The uncertainties attached to the method, however, render it practically impossible to obtain any reliable result. From the observations of geologists in different parts the maximum thickness of the deposits laid down during the various geological epochs has been estimated, but the accuracy of the measurements decreases with the increasing antiquity of the formation concerned, until, when pre-Cambrian times are reached, anything but the merest guesswork becomes impossible. Even were this difficulty removed, the intermediate lapses of time which are represented by unconformities and

other appearances must, of necessity, be disregarded.

When it comes to measurements of the rate of accumulation of the various strata, still greater difficulties are encountered. Theoretically, it is only necessary to measure the annual silt-loads of various rivers, as well as the catchment area, and the rate of deposition ensues. But, in practice, the rates are found to be so divergent and variable that the average counts for little. As Joly points out, we are at liberty to assume anything from a foot to a few inches deposition per century. Taking the rate of accumulation to be four inches in the century, the age of the sedimentary column, which is between sixty and seventy miles thick by the best estimate, then works out to be about one hundred million years. Sollas gets thirty millions; Joly gets eighty million years. The latter is probably the more likely of the two, so we shall not be far wrong if we consider our one hundred-million year computation as fairly near the mark.

IV.—RADIOACTIVITY.

Among the many wonderful possibilities which radioactivity has to offer, the determination by its aid of the age of the earth may be the least important; but it is undoubtedly one of the most interesting, opening up as it does such a splendid field for discussion and speculation.

In the first place, it deals the death-blow to Kelvin's thermodynamic method. The disintegration of a radioactive body is known to be accompanied by a spontaneous evolution of heat energy, and, considering the widespread character of these bodies throughout the earth's crust, the total heat developed in this way can be no negligible quantity. Indeed, so far as present estimates go, it *more* than accounts for the earth's annual loss by radiation—truly an embarrassing position for the earth, as will be shown in a moment. The supposition, then, that the earth is merely a cooling body, whose primitive stock of heat is being slowly depleted, must be modified in order to take account of the new factor. Let us examine afresh our conception of the life-history of the earth.

The fact that the molten earth contains a considerable store of long-lived radioactive elements would not appreciably retard its cooling until the *consistentior status* was reached. Then, on the formation of the surface crust, the rate of cooling would be reduced to a very small fraction of its former value; comparable, in fact, with the heat liberated during elemental disintegration. Near the surface of the earth this heat is sufficient, we have seen, to make good the radiation loss; whereas in the interior, where escape is impossible, the heat generated cannot but have accumulated during the long geological epochs. The final result is evident. Not from without, by collision with some wandering star, but from within, by her own irrepressible vulcanicity, is the destruction to come which is to return the earth to her pristine state, to begin again her life-history, perhaps for the *n*th time, where *n* represents an unknown quantity. In a similar way the long duration of the sun's heat is accounted for, and another theory of Kelvin's exploded.

But let us get back to age determination. The basis of the radioactivity method will be clearly understood if it be remembered that radium is an element whose parentage is known and whose descendants to many generations have been fairly definitely established. In other words, this singular element has been proved to be one of a series which begins with uranium and proceeds down a scale of radio-elements of diminishing atomic weight until the final stable substance, now thought to be lead, is reached. The disintegrating process is accompanied at almost every stage by a loss of what are called α particles, which themselves have recently been shown to be identical with helium atoms.

Of course, the process of degradation is inconceivably slow, though the time-rate for each stage has actually been calculated from laboratory observations. The number of helium atoms discarded during each of the transformations is likewise known. Assuming, then, that all these discharged atoms have accumulated *in situ* in any geological formation, it is only necessary to determine in a specimen mineral the ratio of the occluded helium to the still-remaining radioactive element in order to arrive at an estimate of the age of the strata from which the mineral was taken.

The Hon. R. J. Strutt, in particular, has examined from this point of view many minerals taken from strata of the different geological epochs. His results are too numerous to quote, but so far they have not been particularly satisfactory. Even in material obviously contemporaneous, for instance, the variations in the geological ages turn out to be very considerable. The weak point of the whole method seems to lie, not in the theoretical assumptions involved, but rather in the improbability of a complete helium accumulation. It appears likely that the varying experiences to which the helium-bearing formations have been subjected throughout their existence—such as changes of temperature and pressure or the solvent action of percolating waters—have all contributed to an appreciable alteration in the amount of helium accumulated. The advantage that the method otherwise possesses, in that each determination is an independent estimate of the geological age, is thus swamped by the disability just referred to, and any results which are the outcome of such a method must consequently be received with caution.

The problem has recently been approached from another standpoint, and, at first sight, one more reliable. If lead is really the ultimate product of the disintegration of uranium—and much evidence has been adduced in support of this view—then from the uranium-lead ratio supplementary estimates are possible. Professor Boltwood has attacked the problem of the age of the earth from this assumption, and is led thereby to attribute to a number of uranium-bearing minerals an age which ranges from

two hundred to one thousand three hundred million years; though since the geological positions of the rocks examined are not available the figures do not convey much.

Considered broadly, the evidence of radioactivity is to assign to the earth an age considerably greater than results from any other method. This either means that the accuracy and, perhaps, the fundamental assumptions, of the other methods are impugned, or that the radioactivity method itself is founded upon hyphotheses which are not justifiable. There is even some reason for believing that the latter is not altogether out of question. Thus, though no acceleration in the rate of disintegration of uranium has yet been observed in the laboratory, it is not beyond the pale of possibility that some conditions did prevail in the earlier stages of the earth's history which are not experimentally realisable to-day, but which then determined an increase in the rate of decay. It would be unwise, however, to pursue speculation further, notwithstanding an innate desire to cast doubt upon a method which, by disturbing the gradual maturing and stabilisation of our views before its appearance, has thrown us back into what Professor Schuster describes as "the primitive state where no opinion is absurd and every hypothesis justifiable." Until further evidence of a more convincing nature is forthcoming, we may provisionally assign an age of not less than one hundred million years to this earth of ours.

Of course, this estimate takes us back only to the *consistentior status*. Whether, before that, the sun was still pouring his beneficent rays upon the earth, so that the present estimate of the earth's age is not merely an estimate of the sun's activity, or whether, instead, after solidification of the outer crust, the earth rolled through space as a dead world shrouded in darkness save "where her volcanoes glowed red in the eternal night," cannot be answered decisively. From present evidence it appears very likely that the sun shone brightly long before the earth came into existence, and the one hundred million years would not then have to be very materially increased in order to take us back to the very birth of the earth. On the other hand, it may be that the discrepancies between the results derived from a consideration of denudation and of radioactivity are to be interpreted as pointing to long aeons of time during which the earth slept as she rolled through space.

It would be an interesting diversion to consider whether the whole scheme of evolution outlined by Darwin and others could possibly be worked out within such a comparatively short period as we have accepted. Are one hundred million years time enough for that evolution of the organisms which, starting with a shapeless mass of protoplasm, determined its development through countless structures of increasing complexity, until finally man himself was reached? At this stage only the briefest of answers can be given. Eminent biologists declare that the period *is* ample and the ordinary doubts of the layman may therefore be laid aside.

The period of one hundred million years, then, which have been conceded to the earth, is from most points of view a reasonable estimate. It cannot be expected, however, that finality is attained. This estimate, like its predecessors, may have to be discarded if further investigation requires it, though as yet there seems no valid reason for abandoning it. Nevertheless, our ideas on the subject must be pliant and versatile, our minds ready to recognise the meaning of revolutionary discovery. The best attitude, perhaps, is that which regards the one hundred million years as the earth's *minimum* age, and is prepared, if occasion demands, to consider impartially an estimate of greater—it may be much greater—magnitude.

CORRESPONDENCE.

SPURIOUS DIAMETERS OF STARS.

To the Editors of "KNOWLEDGE."

SIRS,—Reading recently the papers of Sir W. Herschel, published last year by the Royal and Royal Astronomical Societies, I was surprised to see his statement that increase of magnifying power with the same aperture of object glass or mirror causes a decrease in the size of the spurious discs of stars. I was fully under the impression from reading modern works that the reverse was the case. I know that increase of aperture means decrease of diameter of spurious discs, but the other was news to me. Herschel's words are: "By many observations their spurious diameters are lessened by increasing the power, and increase when the power is lowered." In Vol. II., page 303, again he says that the diameter of spurious disc of α Aurigae with power 227 was $2''{\cdot}5$, and that of α Tauri with power 460 was $1''\,46'''$, and with 932 it was $1''\,12'''$, while that of α Lyrae with power 6450 was $0''{\cdot}3553$. I should be glad if some of your astronomical readers would reconcile these extracts with present-day ideas.

THEODORE B. BLATHWAYT.

CAPE TOWN.

STELLAR DISTANCE UNITS.

To the Editors of "KNOWLEDGE."

SIRS,—I notice some comments in your July issue regarding names for the planetary and stellar distance units. In my opinion the names suggested are quite impossible—ugly of look and ugly of speech. The names for any unit of measure should assuredly be short and easy to pronounce. Dr. Crommelin's suggestion of "astron" for one is quite acceptable. But why bother about the inner significance of the words at all? An arbitrary adoption would do quite as well. Why not follow the course adopted in electrical measurements? Here we have "Watts" and "Amperes"; in Astronomy we might well have "Keplers" and "Newtons." Let the former stand for the shorter or earth-sun unit, and the latter for the longer "light-year." In order to destroy the personal look about the terms they might well be abbreviated to "keps" and "newts." As alternatives the names of the men who (*a*) first determined the earth-sun distance and (*b*) who first used the "light-year" of a unit of measure might be used.

A. J. H.

ABERYSTWYTH.

A PLEA FOR A BRITISH FOLK-MUSEUM.

By W. RUSKIN BUTTERFIELD.

A PROPOSAL has recently been made to utilise the Crystal Palace and grounds for a National Folk-Museum on the lines of the famous Nordiska Museet at Stockholm, with its open-air department of Skansen.

The last two decades have witnessed the formation of folk-museums in various parts of Europe, and especially in the Scandinavian countries. In addition to the one mentioned at Stockholm, Sweden possesses others at Lund, and at Bunge in the island of Gotland; in Norway similar institutions have been established at Christiania, Lillehammer, Elverum, and Hamar; and in Denmark at Copenhagen. Their *raison d'être* is to illustrate in a concrete manner the evolution of national culture and characteristics; to trace the modes of life of the people in times past and to preserve representative examples of national buildings, domestic and other appliances, costumes, personal ornaments—in short, to bring together in one locality all such objects as best serve to reconstruct the conditions of life in their respective countries from remotest times.

In no country is a national folk-museum so necessary as in England, because in no other country is there such a dearth of distinctively national objects, and also because no other country has outgrown its past so rapidly and so completely in regard to indigenous customs, amusements, and modes of life generally. What an unalluring sight is presented, for instance, by the interiors of the smaller homes of the land at the present time. The furniture, pottery, and other objects are almost all of the factory type. Here and there, it is true, one does find an old corner cupboard, a lace christening cap, or a piece of slip-ware made at some forgotten local pottery and containing perhaps a presentation inscription commemorating a wedding or a betrothal; but these old folk-objects are few and far between. During the Victorian period especially there existed a profound apathy, if not antipathy, for what was deemed old-fashioned. Mural paintings were hidden behind coats of lime-wash, oak-panelling was torn from the walls, and immemorial seasonal customs in town and village alike dwindled to their final abandonment. No less striking were the changes wrought by the concentration of industries and by increased facilities for transport. Home industries, such as weaving and lace-making, and local crafts, like those of the potter and the basket-maker, were diverted from the villages to factories in the larger centres of population. A national folk-museum would take account of these several changes and preserve the links between the past and the present.

The British Museum at Bloomsbury and the Victoria and Albert Museum at South Kensington are national in scarcely any other sense than that they are State institutions. The splendid collections in the former tell us as much, if not indeed more, about the ancient Egyptians and Greeks than about our own peoples and our own land. The equally fine collections at South Kensington have been accumulated mainly for the special purpose of providing objects, irrespective of their place of origin, to serve as standards in the industrial and fine arts. Moreover, the methods of exhibition in these great museums are only partly in keeping with the spirit of folk-museums. Instead of displaying collections in formal series in standardised glass cases, the folk-museums assemble their objects so far as possible in related groups. But the great failing of the museums in question lies in their remoteness from the realities of every-day life. They restrict themselves too rigidly to things which are merely rare or precious, or which attain a certain artistic merit. They pay little or no concern to the ordinary man and woman. In other words, they touch the circle of national life only at the glowing centre instead of reaching to the wide periphery.

Now let us turn to the proposed scheme and see, so far as is possible in a bare outline, what it is intended to accomplish. Taking the Crystal Palace grounds first, it is proposed to establish therein an open-air museum. Of all the survivals from former times, none surpass in interest the people's homes. The first duty, therefore, of the open-air museum would be to secure ancient houses bearing in a sufficiently well-marked manner features distinctive of some period or locality. The buildings would be taken down and re-erected in the grounds with scrupulous regard to their original form. It is not contemplated, it need hardly be said, to ransack the English countryside and tear buildings from their time-honoured sites, where there is no danger of their demolition or serious mutilation, but to rescue here and there worthy and typical buildings in imminent danger of destruction. After their re-erection the houses will be provided with contemporary furniture and all appropriate appliances, the idea being to show them exactly as they appeared to the people of the time. Some of the houses might have associated with them old English gardens, with a columbarium, a well-house, a sundial, and clipped yews. Consider how fascinating such sights would be, not only to ourselves, but also to visitors from amongst our kinsmen in the dominions beyond the seas.

In some cases, instead of removing whole houses,

XUM

it would be sufficient to secure the ceiling, a fireplace, a panelled room, or the main staircase, and to instal these in rooms in the Crystal Palace.

Besides domestic buildings, other structures would be treated in the same way, such as ancient barns and water-mills. It might even be possible to save some abandoned and decaying English church whose preservation is demanded by its age or importance. Such a church would form the most appropriate home for the display of ecclesiastical art. No doubt many people would find it hard to assent to the removal of a church from its parish, but such removal and preservation are better than decay and final ruin.

The scheme provides for the assignment of a portion of the grounds for our great national games and pastimes; here would be a maypole for the children and a bowling green for their elders. A dancing floor would be laid out for national dances, and an open-air theatre prepared for the performance of historical pageants and stage plays. At Skansen, spacious enclosures are reserved for living examples of Swedish mammals and birds. This might be imitated by a miniature British "Zoo."

As to the Crystal Palace itself, it would serve for the exhibition of objects of all sorts illustrating the daily life, occupations, and amusements of the peoples of these islands. One room could be devoted to children's toys, another to objects used by women in indoor amusements, another to the apparatus and methods of producing fire in past times (a most seductive subject), another to inventions, another to models to enable the blind to gain, by tactual means, a knowledge of some of the more interesting objects in the various departments. Space would further be required for developmental series of English metal-work, wood-carving, pottery, glass, furniture, and textiles; also for such things as hand-looms, vehicles, old surgical instruments, inn-signs, the regalia of guilds and other societies, stocks, gibbets, clocks, tallies, charms, cheese-presses, and a multitude of others. Special stress would be laid upon objects typified by ornamental lace-bobbins, carved bone apple-scoops, and costumes, as it is just such things as these that best illustrate the trend of native culture.

The framers of the scheme point out that it would be particularly appropriate if a number of rooms in the Crystal Palace could be devoted to collections relating to past and present members of our Royal house, such as portraits, ceremonial robes, and personal relics. The present writer had hopes at one time that Stafford House might be converted into a royal museum after the fashion of Rosenborg Castle at Copenhagen, but the future of that building has been settled otherwise.

A national folk-museum like this would illustrate, by means of actual objects, historical continuity. After all, the present can only be measured in terms of the past, and, unhappily, in England our past is rapidly disappearing beyond recall. If the project is delayed much longer its effectual accomplishment will become impossible. Other European countries are fully alive to the importance of preserving unbroken the records of national life. There is little in our past to be ashamed of; there is much of which we may justly be proud.

Through the patriotic action of Lord Plymouth, Sir David Burnett, and of *The Times*, the Crystal Palace grounds are now available for some public purpose. It is desirable, from every point of view, to take advantage of so unique an opportunity for promoting the establishment of a permanent and comprehensive national folk-museum. The central feature of the situation lies in the fact that, if these grounds are assigned to some other use, no other open stretch of land so near London of such magnitude can ever again be forthcoming. It is a duty we owe to posterity no less than to our forbears, to preserve, while it is still possible, the fast dissolving links that bind us with the past.

I wish to express my indebtedness to Mr. Bernhard Olsen, of the Dansk Folkemuseum, Mr. Hans Aall, of the Norsk Folkemuseum, Mr. Bernhard Solen, of the Nordiska Museet, and Dr. Anders Sandvig, founder of Maihaugen Open-air Museum, for kind permission to reproduce the accompanying illustrations; also to Dr. F. A. Bather and Professor Henri Logeman for valued assistance.

THE ARTIFICIAL RIPENING OF FRUITS.

The Gardeners' Chronicle for July 19th points out that the Arabs have for centuries ripened dates artificially by exposing them to the fumes of vinegar; and refers to the ripening of persimmons by the Japanese, who store them in a closed cask in which the national alcoholic beverage known as saké has been kept. Professor Francis Lloyd's method of exposing unripe fruits under a pressure (of from fifteen to forty-five pounds to the square inch) to the action of carbon dioxide for fifteen to thirty-six hours is also discussed. What happens in the process is not altogether clear, but we quote the following remarks:—

"Astringency is due to the action on the tongue of the tannins contained in the unripe fruit. It disappears if the tannins are destroyed, or if these bitter substances are prevented from acting on the tongue. Carbon dioxide seems to produce the latter effect, and in the following way: Associated with the tannins in plant tissues are coagulable substances. Such substances when caused to coagulate hold the tannins very strongly, so strongly, indeed, that the latter substances are prevented from giving rise to an astringent taste when the fruit containing them is eaten. In short, the coagulated substance plays the part of the coat of a bitter pill, enabling the latter to be taken untasted. The explanation may be that which has been given; but we are inclined to think that other changes are induced by carbon dioxide. For example, it is possible that the effect of carbon dioxide is to hasten the oxidation processes of the tissues, and hence to cause a partial or complete destruction of the astringent substances. Whatever be the precise interpretation of the process the important thing is to ascertain whether a similar process may be induced in our common large fruits; for although artificial ripening is primarily of importance to the grower of tropical fruits—dates, bananas, persimmons, and the like—it may prove also of service to the home grower."

XUM

FIGURE 331. Assemblage of buildings within enclosures forming a "summerset," or temporary quarters occupied during cattle grazing, from Jämtland. Skansen.

FIGURE 332. Timber-houses from Telemarken. Norsk Folkemuseum.

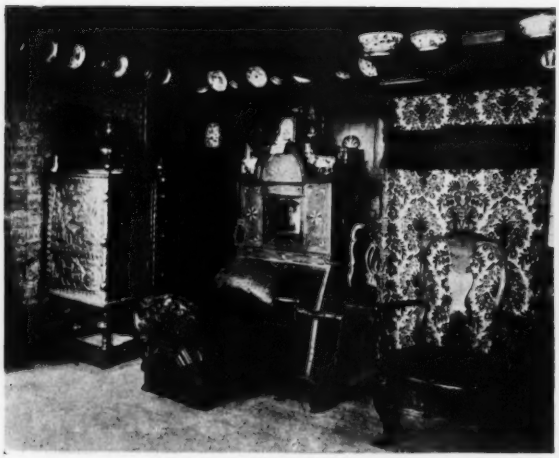

FIGURE 333. Interior of room from a farmhouse, from Amager, near Copenhagen. Dansk Folkemuseum.

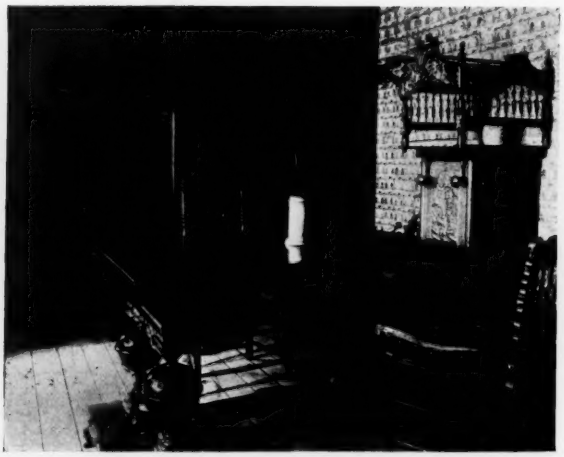

FIGURE 334. Farmhouse interior from Urendorf, Halsatia. Dansk Folkemuseum.

FIGURE 335. Interior from Telemarken. Norsk Folkemuseum.

FIGURE 336. Timber-house ("Rolstadloftet") from Gudbrandsdale. Norsk Folkemuseum.

FIGURE 337. House in the Maihaugen Open-Air Folk-Museum. Lillehammer.

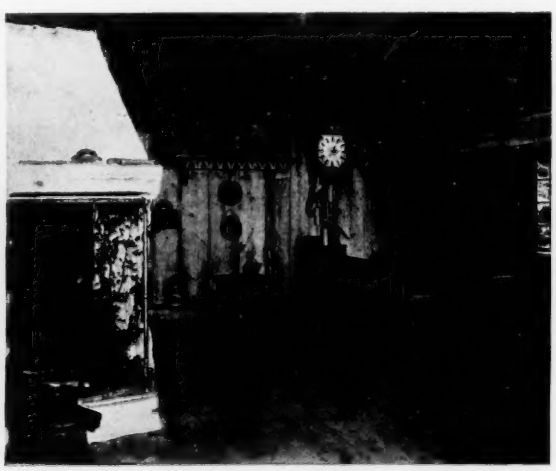

FIGURE 338. Interior of a dwelling at Lillehammer.

THE FACE OF THE SKY FOR SEPTEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 52.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°	h. m.	°	h. m.	°
Sept. 2	10 43·9	N.8·1	12 8·5	S. 1·8	9 56·5	N.14·1	8 13·6	N.13·4	5 26·9	N.22·9	18 34·9	S.23·4	5 6·1	N.21·2	20 27·1	S.19·8
,, 7	11 1·9	6·2	16 46·4	S. 27·6	10 33·0	11·0	8 38·0	18·3	5 39·7	23·1	18 35·0	23·4	5 7·1	21·2	20 26·5	19·9
,, 12	11 19·9	4·3	21 18·5	S. 19·1	11 8·8	7·4	9 2·2	17·0	5 52·1	23·3	18 35·4	23·4	5 7·9	21·2	20 26·0	19·9
,, 17	11 37·9	2·4	0 53·4	N. 7·8	11 43·0	N.3·5	9 26·1	15·5	6 4·3	23·4	18 36·1	23·4	5 8·5	21·2	20 25·5	19·9
,, 22	11 55·8	N.0·5	4 59·2	N.28·0	12 15·3	S.0·5	9 49·9	13·8	6 16·0	23·5	18 37·1	23·4	5 8·9	21·2	20 25·1	19·9
,, 27	12 13·8	S.1·5	9 55·2	N.15·4	12 46·0	S.4·3	10 13·4	N.11·9	6 27·3	23·5	18 38·5	S.23·4	5 9·2	N.21·2	20 24·8	S.19·9

TABLE 53.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
Greenwich Noon.	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Sept. 2	+21·4	+7·2	24·2	+21·8	−28·7	−1·0	227·1	9 6 *e*	−4·6	−1·6	199·9	285·5	4 23 *e*	2 4 *e*
,, 7	22·6	7·2	318·2	+ 6·9	27·5	+0·2	178·9	0 24* *m*	4·6	1·6	269·0	316·5	2 30 *e*	1 13 *e*
,, 12	23·7	7·2	252·2	−16·5	26·2	1·4	130·8	3 2 *m*	4·6	1·6	338·1	347·4	10 27 *e*	0 22 *e*
,, 17	24·5	7·1	186·2	−21·4	24·9	2·5	82·8	6 20 *m*	4·7	1·6	47·1	18·2	8 34 *e*	9 26 *e*
,, 22	25·2	7·0	120·2	− 5·8	23·6	3·5	34·8	9 37 *m*	4·8	1·6	116·0	49·0	6 41 *e*	8 36 *e*
,, 27	+25·8	+6·8	54·2	+18·6	−22·3	+4·5	346·9	0 54 *e*	−5·0	−1·6	184·8	79·6	4 48 *e*	7 45 *e*

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Mars, T is the time of passage of Fastigium Aryn across the centre of the disc. In the case of Jupiter, L_1 refers to the equatorial zone; L_2 to the temperate zone; T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

The asterisk indicates the day following that given in the date column.

THE SUN continues his Southward march with accelerated speed. The equinox is passed $23^d\ 3^h\ 53^m e$. Sunrise during August changes from 5.13 to 5.59, sunset from 6.48 to 5.41. Its semi-diameter increases from 15′ 53″ to 16′ 0″. Outbreaks of spots in high latitudes should be watched for.

MERCURY is in Superior Conjunction $16^d\ 3^h e$; before that it is a morning star. Illumination increases from $\frac{7}{10}$ to Full. Semi-diameter diminishes from 3″ to 2½″.

VENUS is a morning star, rising 3 hours before the Sun. Semi-diameter diminishes from 7″ to 6″. At beginning of month ¾ of disc is illuminated; at end of month ⅝. Being North of Sun it is favourably placed for Northern observers.

THE MOON.—First Quarter $7^d\ 1^h\ 6^m e$; Full $15^d\ 0^h\ 46^m e$; Last Quarter $23^d\ 0^h\ 30^m e$. New $30^d\ 4^h\ 57^m m$. Perigee $1^d\ 7^h m$, semi-diameter 16′ 44″. Apogee 15^d Noon, semi-diameter 14′ 44″. Perigee $29^d\ 6^h e$, semi-diameter 16′ 44″. Maximum Librations, 7^d 8° W, 8^d 7° N., 23^d 7° E., 23^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

ECLIPSES.—A small partial eclipse of the Sun, invisible in Europe, occurs on August 31st, lasting from $8^h\ 2^m e$ to $9^h\ 42^m e$; greatest magnitude 0·15. Visible in Newfoundland, Labrador, Greenland.

A total eclipse of the Moon, invisible in Europe, occurs on September 15th, lasting from $10^h\ 53^m m$ to $2^h\ 44^m e$. Visible over Pacific Ocean, Australia, New Zealand, and so on.

A partial eclipse of the Sun, invisible in Europe, occurs on September 30th, lasting from $2^h\ 56^m m$ to $6^h\ 36^m m$; greatest magnitude 0·83. Visible in South Africa, Madagascar, Mauritius, and South Indian Ocean.

MARS is a morning Star, semi-diameter 4″, defect of illumination nearly a second. It will reach Opposition early in January, so the season of observation is commencing. The Earth is in the plane of Mars' Equator on September 6th; both poles are then on the edge of the disc.

JUNO is in opposition September 14th, magnitude 7·6. Ephemeris for midnight:—

			R.A. h m		S.Dec. °
Sept.	12...	...	23 24·5	...	3·6
,,	18...	...	23 20·2	...	4·9
,,	24...	...	23 16·1	...	6·1
,,	30...	...	23 12·3	...	7·3

SATURN is a morning star, coming into a better position for observation. Polar semi-diameter 8½″. P. is −4°·9; ring major axis 43½″, minor 19½″. The ring is very widely open. It is of interest to examine the exact amount of overlap beyond the planet's pole.

East Elongations of Tethys (every fourth given), $3^d\ 4^h{\cdot}9e$, $11^d\ 6^h{\cdot}1m$, $18^d\ 7^h{\cdot}4e$, $26^d\ 8^h{\cdot}6m$; Dione (every third given), $6^d\ 11^h{\cdot}1e$, $15^d\ 4^h{\cdot}2m$, $23^d\ 9^h{\cdot}3m$; Rhea (every second given), $2^d\ 4^h{\cdot}8m$, $11^d\ 5^h{\cdot}7m$, $20^d\ 6^h{\cdot}6m$, $29^d\ 7^h{\cdot}5m$. For Titan and Iapetus E.W. mean East and West Elongations; I. Inferior (North) Conjunctions, S. Superior (South) ones. Titan, $3^d\ 5^h{\cdot}7e$ W., $7^d\ 5^h{\cdot}2e$ S.; $11^d\ 8^h{\cdot}4e$ E., $15^d\ 8^h{\cdot}4e$ I., $19^d\ 4^h{\cdot}9^d$ W., $23^d\ 4^h{\cdot}3e$ S., $27^d\ 7^h{\cdot}4e$ E.; Iapetu , $9^d\ 5^h{\cdot}3m$ S., $29e$ $6^h{\cdot}0e$ E.

URANUS was in opposition on July 29th. Semi-diameter, 1¾″. At end of August, 2° S.E. of ρ Capricorni.

TABLE 54. Occultations of stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. to E.	Mean Time.	Angle from N. to E.
1913.			h. m.		h. m.	
Sept. 4 ...	BAC 4722	5·5	7 13 *e*	67°	—	—
,, 6 ...	Lacaille 6719	6·9	7 13 *e*	63	—	—
,, 6 ...	Stone 8802	7·0	7 49 *e*	89	—	—
,, 8 ...	γ^1 Sagittarii	var.	4 53 *e*	84	6 13 *e*	281°
,, 9 ...	BAC 6525	6·2	7 54 *e*	121	8 51 *e*	211
,, 10 ...	A Sagittarii	4·9	5 53 *e*	80	7 14 *e*	252
,, 14 ...	h^1 Aquarii	5·4	6 2 *e*	4	6 35 *e*	302
,, 17 ...	BD+ 9°142	7·1	—	—	9 29 *e*	270
,, 19 ...	BD+15°305	7·5	—	—	2 8 *m*	180
,, 19 ...	BD+18°347	6.9	—	—	9 14 *e*	210
,, 20 ...	BD+19°432	7·0	—	—	1 39 *m*	275
,, 20 ..	47 Arietis	5·8	2 53 *m*	116	3 43 *m*	193
,, 20 ...	9 Tauri	6·7	—	—	8 58 *e*	219
,, 20 ...	17 Tauri	3·8	11 58 *e*	62	1 9* *m*	248
,, 21 ...	16 Tauri	3·8	0 17 *m*	20	1 7 *m*	289
,, 21 ...	20 Tauri	4·1	0 46 *m*	28	1 45 *m*	282
,, 21 ...	η Tauri	3·0	1 38 *m*	138	2 2 *m*	174
,, 21 ...	24 Tauri	6·8	—	—	2 8 *m*	189
,, 21 ...	BD+23°540	7·0	—	—	2 37 *m*	230
,, 21 ...	BAC 1171	6·6	—	—	3 11 *m*	221
,, 25 ...	C Geminorum	5·5	2 30 *m*	48	3 12 *m*	326

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.
The asterisk indicates the day following that given in the date column.
Attention is called to the occultation of the Pleiades on the 21st; the stars from 17 Tauri to BAC 1171 belong to the group.

NEPTUNE is too near the Sun for convenient observation, having been in conjunction on July 19th.

JUPITER was in opposition on July 5th. Polar semi-diameter, 19″ in mid-September.

Satellite phenomena visible at Greenwich, $1^d\ 7^h\ 29^m$ I. Sh. I., $8^h\ 38^m$ I. Tr. E., $9^h\ 48^m$ I. Sh. E., $10^h\ 31^m$ III. Tr. I., $10^h\ 47^m\ 41^s$ IV. Ec. D.; $2^d\ 7^h\ 3^m\ 46^s$ I. Ec. R.; $5^d\ 8^h\ 39^m\ 4^s$ III. Ec. R., $11^h\ 15^m$ II. Tr. I.; $7^d\ 10^h\ 50^m\ 6^s$ II. Ec. R., $11^h\ 1^m$ I. Oc. D.; $8^d\ 8^h\ 12^m$ I. Tr. I., $9^h\ 25^m$ I. Sh. I., $10^h\ 30^m$ I. Tr. E.; $9^d\ 7^h\ 56^m$ IV. Tr. I., $8^h\ 58^m\ 46^s$ I. Ec. R., $10^h\ 57^m$ IV. Tr. E.; $12^d\ 7^h\ 37^m$ III. Oc. R., $9^h\ 25^m\ 32^s$ III. Ec. D.; $14^d\ 8^h\ 4^m$ II. Oc. D.; $15^d\ 10^h\ 5^m$ I. Tr. I.; $16^d\ 7^h\ 21^m$ I. Oc. D., $8^h\ 22^m$ II. Sh. E.; $17^d\ 6^h\ 51^m$ I. Tr. E., $8^h\ 8^m$ I. Sh. E.;

TABLE 55. NON-ALGOL STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m.	°		d.	
RU Aquilae	20 9	+12·7	7·9 to 14	276	Aug. 22.
R Sagittae	20 10	+16·5	8·5 to 10	70·6	July 20, Sep. 29.
AI Cygni	20 28	+32·2	8·6 to 9·7	173	Aug. 27.
V Cygni	20 38	+47·8	6·8 to 14	418	June 29.
T Aquarii	20 45	−5·5	6·8 to 13	202·7	July 30.
R Vulpeculae...	21 1	+23·5	7·1 to 13	136·8	Aug. 30.
T Cephei	21 8	+68·2	5·2 to 11	387	Oct. 24.
SW Pegasi	21 18	+21·6	8·7 to ?	175	July 10.
YY Cygni	21 19	+42·0	8·5 to 9·5	378	Sep. 29.
S Cephei	21 36	+78·2	7·0 to 13	486	June 24.
V Pegasi	21 57	+5·7	7·8 to 14	303	Sep. 8.
X Aquarii	22 14	−21·3	7·6 to 11	315	July 31.
TX Pegasi	22 14	+13·2	8·5 to 9·2	123	July 20, Nov. 20.
S Lacertae	22 25	+39·8	8·0 to 12·5	237·5	July 29.
R Lacertae	22 39	+41·9	8·3 to 13·9	299·8	July 1.
U Lacertae	22 44	+54·7	8·5 to 9·1	659	July 5.
S Aquarii	22 52	−20·8	8·0 to 14·5	279·7	July 25.
SS Andromedae	23 8	+52·4	8·9 to 9·6	165·8	Aug. 5.
TV Andromedae	23 10	+40·3	8·2 to 9·6	144	Oct. 19.
W Pegasi	23 15	+25·8	7 to 13	342·6	Aug. 13.
S Pegasi	23 16	+8·4	7·3 to 13·1	317·5	Aug. 10.
R Aquarii	23 39	−15·8	6·0 to 10·8	387·16	Oct. 6.
V Cephei	23 52	+82·7	6·2 to 7·0	362	Nov 20.
R Cassiopeiae...	23 54	+50·9	4·8 to 13·2	431·6	July 21.
Y Cassiopeiae...	23 59	+55·2	8·4 to 13·9	410	Nov. 22.

β Lyrae minima Sept. $5^d\ 2^h\ m$, 17^d midnight, $30^d\ 10^h\ e$, Period $12^d\ 21{\cdot}8^h$.

Algol minima Sept. $3^d\ 0^h\ 11^m\ m$, $5^d\ 9^h\ 0^m\ e$, $23^d\ 1^h\ 54^m\ m$, $25^d\ 10^h\ 43^m\ e$, $28^d\ 7^h\ 32^m\ e$, Period $2^d\ 20{\cdot}8^h$.

$18^d\ 8^h\ 16^m\ 58^s$ IV. Ec. R.; $19^d\ 8^h\ 10^m$ III. Oc. D.; $23^d\ 6^h\ 36^m$ III. Sh. E., $8^h\ 5^m$ II. Sh. I., $8^h\ 22^m$ II. Tr. E., $9^h\ 15^m$ I. Oc. D.; $24^d\ 6^h\ 27^m$ I. Tr. I., $7^h\ 45^m$ I. Sh. I. $8^h\ 45^m$ I. Tr. E., $10^h\ 4^m$ I. Sh. E.; $25^d\ 7^h\ 17^m\ 37^s$ I. Ec. R.; $30^d\ 7^h\ 11^m$ III. Sh. I., $8^h\ 5^m$ II. Tr. I. All these are in the evening hours, the planet setting before midnight.

TABLE 56.

Day.	West.	East.	Day.	West.	East.
Sep. 1		⊙ 342	Sep. 16	432 ○	1 ●
,, 2	32 ○	14	,, 17	3241 ○	
,, 3	321 ○	4	,, 18	3 ○	1½
,, 4	3 ○	124	,, 19	13 ○	24
,, 5	1 ○	24 3 ●	,, 20	2 ○	134
,, 6	2 ○	134	,, 21	12 ○	34
,, 7	1 ○	34 2 ●	,, 22	○	1324
,, 8	○	1324	,, 23	31 ⊙	4
,, 9	32 ⊙	1 ●	,, 24	32 ⊙	4
,, 10	3421 ○		,, 25	3 ○	124
,, 11	43 ○	12	,, 26	134 ○	2
,, 12	41 ○	32	,, 27	42 ○	13
,, 13	42 ○	13	,, 28	412 ○	3
,, 14	412 ○	3	,, 29	4 ○	123
,, 15	4 ○	132	,, 30	413 ○	2

Configuration at 8^h *e* for an inverting telescope.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 20^h to 0^h, next month 22^h to 2^h, and so on.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
	°	°	
June to Sep...	335	+ 57	Swift.
July 25 to Sept. 15	48	+ 43	Swift, streaks.
July to Sept...	335	+ 73	Swift, short.
July to Oct. ...	355	+ 72	Swift, short.
Aug. to Sept. .	353	− 11	Rather slow.
,, ,,	346	0	Slow.
Aug. to Oct. 2.	74	+ 42	Swift, streaks.
,, to Sept...	63	+ 22	Swift, streaks.
Sep. 5-15 ...	62	+ 35	Swift, streaks.
,, 6-17 ...	106	+ 52	Swift, streaks.
,, 15-24 ..	14	+ 6	Slow.
,, 21 ..	31	+ 19	Slow, trains.
,, 27-30 ...	4	+ 28	Slow.
,, 28 to Oct 9	320	+ 40	Slow, small.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE LIGHT-VARIATION OF EROS.—It will be remembered that at the time of the near approach of Eros at the end of 1910 and beginning of 1911 a large variation was detected in its brightness; there was a question whether the period was five hours or two and a half hours; it appears that the full period is five hours, but that it is made up of a double wave with unequal maxima, like some variables (Beta Lyrae has the maxima equal, the minima unequal). At the opposition of 1903 Eros was far south, and Professor S. Bailey made most careful observations on the variability at the Arequipa Observatory. The visual and photographic methods confirmed each other, and showed that the five-hour period is correct; the exact value is 0·2196 day, but this has not been corrected for the changing position of the planet. Taking the minimum brightness as zero, the following tables give the excess of brightness (in stellar magnitudes) over minimum light at intervals of one-twenty-fourth of the period, beginning at principal maximum. The upper set is derived from the visual measures, the lower from the photographic:—

·63, ·57, ·44, ·27, ·10, ·01, ·00, ·06, ·19, ·34, ·47, ·55, ·56
·50, ·40, ·29, ·14, ·02, ·00, ·07, ·22, ·39, ·53, ·61.

·51, ·47, ·39, ·28, ·15, ·05, ·00, ·00, ·07, ·16, ·29, ·38, ·43,
·43, ·37, ·29, ·16, ·05, ·00, ·00, ·07, ·21, ·36, ·47.

The two curves are in good agreement, and show a range of fully half a magnitude. The maxima differ by ·07; the reality of the double maximum is probable, but it appears possible that there is really only a single wave with half the period. The most probable cause of the variation seems to be irregular shape of the planet. In such a tiny body gravity is very weak, and insufficient to form a regular shape. This seems more likely than the suggestion made by Professor Turner that it may have spots on its surface of very different albedoes. On such a tiny world anything in the nature of cloud or snow is out of the question, for it could not retain an atmosphere. Also organic rocks like chalk are excluded. It seems not impossible that at the near approach of 1931 our giant telescopes may be able to see Eros as a tiny disc (it should be quite half a second in diameter) and detect any notable departure from roundness; double stars half a second apart are easily separated in large instruments.

There is no reason to think that Eros is the only small planet whose shape is irregular—many have therefore been observed at Arequipa for variability. Three gave definite light-curves: Sirona has a period of $0^d{\cdot}403$, range one-half magnitude; Celuta period $0^d{\cdot}364$, range one-half magnitude; Tercidina period $0^d{\cdot}366$, range one-half magnitude; its variation had already been detected by Wolf and Wendell. Variation was suspected in Hecuba and Urania, but not fully established. It would seem that the asteroids as a class have pretty rapid rotation from the periods of those that vary.

THE WORK OF HARVARD OBSERVATORY.—We had the pleasure of hearing both Professor E. C. Pickering and Miss Cannon at the meetings of the R.A.S. and the B.A.A. in June, and we formed some idea of the immense scale of their work. Miss Cannon is directing the preparation of a catalogue of the spectra of one hundred thousand stars, which will be practically exhaustive down to magnitude 8, and will contain many fainter stars. This is, of course, made from photographs taken with a prismatic camera; it would be out of the question to obtain so many spectra with a slit spectroscope; the latter is, of course, better for large-scale spectra of bright stars, or for motion in the line of sight, which can only be deduced in an indirect and unsatisfactory way from the prismatic camera. This, however, gives a considerable amount of detail even with faint stars, and wave-lengths of lines can be deduced differentially. Miss Cannon is so intimately acquainted with all the types of spectra and their subdivisions that she can assign them to their different classes with great rapidity; subsequently her assistants identify the stars and prepare the catalogue. No fewer than fifteen Novae were discovered at Harvard by their spectra, ten by the late Mrs. Fleming. Many other stars having bright lines in their spectra have been discovered. Professor Pickering states that with a slit-spectroscope only about two per cent. of the stars'

XUM

light is utilised, as atmospheric unsteadiness continually moves its image off the slit. With the prism before the object-glass there is little loss of light, no guiding is required; the spectra are given any desired width by allowing them to trail on the plate.

APPEAL FOR MORE VOLUNTEERS FOR OBSERVATION OF VARIABLE STARS.—The June number of *Publications of the Astronomical Society of the Pacific* has an article on this subject by Mr. E. Gray. He points out what a suitable field this is for amateurs with a small equipment; a good binocular suffices to observe the brighter variables, while a very large field of work is open to the possessor of a three-inch telescope: it need not be equatorially mounted, though if not it is necessary to commit to memory the field surrounding each star studied, so as to be able to identify it without loss of time. For the brighter variables the observer can make sketches of the fields for himself; for the fainter ones he should procure Father Hagen's Atlas. The article quotes the case of an observer who had only a three-inch on a tripod stand who was able to observe twenty-six variables on one evening and to finish work at 8.50 p.m. There is the charm of uncertainty about this work, for while some of the stars are regular, others are subject to large irregularities, and there is the possibility that assiduous work may find the law of these fluctuations. X Monocerotis is quoted as a typical star for which more observers are needed to follow it through all its stages (it does not go below the tenth magnitude). Beginners are more likely to persevere if they take up work that they know is of real utility than if they merely do aimless star-gazing. A further attraction is added to this field of work by the rich red colour of many of the stars.

THE PLANET ALBERT.—The same publication contains an account of Dr. Haynes's work on this planet (better known as MT). He is taking the three undoubted observations of 1911, October 3rd, 4th, and 11th, and combining them one by one with each of the other eight doubtful places, so as to get a series of orbits one of which is presumably right. Search will be made in all possible positions when a favourable opposition recurs. The planet was in opposition last spring, but only of magnitude 19 or 20. Search was, however, made with the Crossley Reflector at Lick, and three faint planets found, but it appeared that none of them could be Albert. I am glad to note that Dr. Haynes has received the degree of Doctor of Philosophy in the University of California in recognition of this work.

THE TROJAN GROUP OF PLANETS.—The same magazine has an article on this group by Dr. S. Einarsson. They nearly conform to the equilateral configuration with the Sun and Jupiter, which Laplace showed to be an exact solution of the three-body problem. The present paper shows that it is both simpler and more accurate to deal with the motion on this basis from the first than to treat Jupiter's action as a mere perturbation.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

THE "AFTER-RIPENING" OF SEEDS.—In many cases seeds require a long time for germination, usually owing to the exclusion of water or of oxygen by the seed-coat. After excluding such cases, however, there are some plants left in which the seed does not grow, even when the coat has been removed and the embryo put in good germinating conditions, until a certain period has elapsed, during which some change is evidently taking place in the embryo. To such cases the term "after-ripening" is strictly applied, and Miss S. Eckerson has just made a careful study of this phenomenon (*Bot. Gaz.*, Vol. LV). It has been found that seeds of various pines show a delay in germination of as much as two years, while those of ash sown in spring do not germinate until the following spring. In the latter case the embryo in the mature seed occupies about half the space within the endosperm, the rest being occupied by a mucilaginous substance; during the year that the seed lies in the ground the embryo grows in length and fills the seed-coat; hence a period of growth is necessary before germination.

The authoress has studied the delayed germination or "after-ripening" of the hawthorn (several species of *Crataegus*). She finds that food is stored in the embryo in the form of fatty oil; lecithin is also present, but there is no starch or sugar. The reäction of the cotyledons is acid, but the hypocotyl is slightly alkaline. During the after-ripening period there is a series of metabolic changes in the embryo, beginning with increased acidity, and correlated with this there is an increased water-absorbing power, and also an increase in the activity of the ferments catalase and peroxidase. Near the end of this period there is a sudden increase in the acidity and in the water content; here oxidase first appears. All of these increase until the hypocotyl is three to five centimetres long; then fats decrease and sugar appears, while hydrocyanic acid is present in the cotyledons. The after-ripening period can be greatly shortened by treating the embryo with dilute acids; the water-holding power, the acidity, and the amount of peroxidase increase much more rapidly, and oxidase appears much earlier, than in untreated embryos. Apparently there is a correlation between the acidity of the hypocotyl of *Crataegus*, its water-absorbing power, production of ferments, and germinating power. Whether the acidity is causal or merely correlative is not known, though there is some evidence that it is causal—for instance, it has been found to lead to the liberation of ferments, and to increase the water-absorbing power of colloids.

BACTERIAL NODULES ON LEAVES.—All students of plant life are doubtless familiar with the remarkable nodules found on the roots of Leguminosae and a few other plants (*Alnus*, *Myrica*, *Podocarpus*, and so on) and containing bacteria which fix free atmospheric nitrogen and thus supply the "host" plant with nitrogenous food. Faber (*Jahrb. f. wiss. Bot.*, 1912) describes an interesting and unexpected symbiosis of a similar kind which he has discovered in two tropical genera (*Pavetta* and *Psychotria*) belonging to the Rubiaceae; but here the nodules are developed on the leaves instead of the roots. The bacteria have the same power of nitrogen fixation as those in the roots of Leguminosae. They are already present in the unopened bud, lying in the cavity formed by the stipules of the leaf, and they enter the leaves themselves by way of the stomata, collecting in the air cavity just below a stoma and multiplying so as to disturb the shape of the surrounding cells of the leaf, which appear to be stimulated to vigorous division, resulting in the formation of a mass of small-celled tissue. In this tissue there are relatively large intercellular spaces, and in these the bacteria grow, though without apparently injuring the cells. After the bacteria have entered and set up the formation of the nodule or "gall," the stoma becomes occluded, shutting them in; the plant has, so to speak, swallowed the bacteria. The tissue in the swelling contains abundant chlorophyll and starch grains, but when the nodule is fully formed the starch disappears and is replaced by reducing sugar, evidently formed by fermentation of the starch. Finally, towards the close of the leaf's life the bacteria have largely disappeared from the intercellular spaces and the cells again contain abundant starch; hence the food apparently serves for the nutrition of the bacteria—as one might say, in return for the service rendered by them to the plant in supplying the latter with nitrogenous compounds manufactured from the atmosphere. In a variegated form of *Pavetta indica* these remarkable leaf nodules are conspicuous as green swellings on the otherwise white leaf.

The author believes that this represents an ideal case of symbiosis between bacteria and higher plants, though the latter gets the better exchange, since ultimately the cells of the leaf, whether or not they actually cause the death of the bacteria, at any rate absorb their dead remains; the walls of the bacterial cells become slimy, and eventually they disappear. The bacteria, which closely resemble the tubercle bacillus, occur in the seed, lying between the embryo and the endosperm,

and after germination they are found occupying the growing tip of the young shoot, so that the relationship between the bacteria and the higher plant is extremely intimate and begins at a very early stage. The author killed the bacteria with hot water without injuring the embryo, and found that the young plants thus sterilised, or freed from bacteria, grew very slowly and had small leaves as compared with normal or infected plants. Sand cultures of sterilised and unsterilised seedlings showed that the former died in the absence of a supply of nitrogenous food materials, while the latter grew quite well. Precautions were taken in these cultures to exclude other micro-organisms.

CYTOLOGY OF BACTERIA.—In a long paper on the cytology of bacteria, Dobell (*Q.J.M.S.*, Vol. LVI) prefaces his own observations by a useful and interesting summary of previous work on the structure of bacteria, with special reference to the methods of fixation and staining used by the various investigators and to their conclusions concerning the presence or absence of a nucleus in these organisms. He examined a large number of forms, obtained from the intestines of various animals, and arrived at the following conclusions. All bacteria which have been adequately investigated have a nucleus; but the form of the nucleus is variable, not only in different bacteria, but also at different periods in the life-cycle of the same species. The nucleus may be in the form of a loose system of granules (chromidial nucleus); or of a filament of variable configuration; or of one or more relatively large aggregated masses of nuclear substance; or of a system of irregularly branched or bent short strands, rods, or networks; and probably also in the vesicular form characteristic of many plants, animals, and protista. There is no evidence that non-nucleate bacteria exist. The author considers it highly probable that the bacteria are in no way a group of simple organisms, but rather a group displaying a high degree of morphological differentiation, coupled in many cases with a life-cycle of considerable complexity.

BIOLOGY OF THE PITCHER-PLANT *DISCHIDIA*.—In the genus *Dischidia* belonging to the Asclepiadaceae and found in the East Indies as epiphytes climbing by adventitious roots and having fleshy wax-clad leaves, some species have, in addition to ordinary leaves, remarkable pitcher-leaves. Each of these is a pitcher with an incurved margin and about four inches deep; but their biology is very different from that of such pitcher-plants as *Nepenthes*. Into the pitcher there grows a root which arises from the stem or from the leaf-stalk close to the pitcher, and this root ramifies among the humus and other débris which is apparently largely carried into the pitcher by ants. The pitcher also catches rain-water, hence it serves as a humus collector and water reservoir; the inner surface is coated with wax, hence the water cannot be absorbed by the pitcher itself, nor lost by passing through the walls, but must be absorbed by the roots; the inner surface of the pitcher also bears stomata, and doubtless the water-vapour given out through these is condensed in the pitcher.

Some further details of the biology of *Dischidia* have recently been given by Kerr (*Proc. Roy. Dublin Soc.*, Vol. XIII) from observations made on the pitcher-bearing species *D. Rafflesiana* and on *D. nummularia* in their native habitat in the jungles of Northern Siam. The plants are associated with two species of ant (*Iridomyrmex myrmecodiae*, *I. cordex*). In *D. nummularia* the ants are found below the leaves, where they form nests of clay and vegetable débris in which the roots of the *Dischidia* branch; while in *D. Rafflesiana* the ants make their nests within the pitchers and plaster clay above the bases of the pitchers and over the roots. The flowers are pollinated by bees, but the ants assist in the dispersal of the seeds, removing them for food—the seeds not eaten germinate along the ants' tracks. The author concludes that in *D. Rafflesiana* the pitchers do not so much store water as serve to economise the water vapour of transpiration and also provide shelters for ants, which in return supply the roots with food material.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

ARGON AND ITS PLACE IN NATURE.—An outline of a communication on this subject made by Sir William Ramsay, to the Chemical Society of Rome, is given in the *Chemical Trade Journal* (1913, LII, 595). The experiments of Professor Collie and Mr. Paterson, which indicated the formation of helium and neon from hydrogen, have been repeated and their results confirmed. In the opinion of Sir William Ramsay dry hydrogen becomes polymerised into helium, when subjected to the action of cathode rays in a vacuum tube, while for the production of neon the presence of oxygen is necessary. This might be derived either from a trace of moisture or from the bombardment of the glass by the rays. When the experiment was modified by placing dry hydrogen in a vacuum tube and passing an electric discharge for five or six hours between an aluminium cathode and anode, which were coated with sulphur, argon was produced, but no trace of helium or neon could be detected. Again, when the electrodes were coated with selenium instead of sulphur the gas, after the experiment, showed the characteristic lines of the krypton spectrum. The three elements neon, argon, and krypton, the atomic weights of which are in an ascending scale, have thus apparently been produced from hydrogen in the presence of oxygen, sulphur, and selenium respectively—elements which stand in an analogous relationship towards each other.

BIOLOGICAL METHOD OF IDENTIFYING SEEDS.—The precipitin method of distinguishing between the flesh and blood of different species of animals was described some years ago in these columns. In brief, it is based upon the fact that when the serum of a particular animal is injected into, say, a rabbit, the serum of the latter becomes immunised, and when subsequently the rabbit is killed its serum will give a precipitate with the serum of animals of the species to which it was rendered immune, but not with the serum of an animal of another species.

This method has now been successfully applied to the identification of the seeds of different plants, and an account of the process devised by Relander is given by Dr. Zade in the *Bull. Agric. Intel. and of Plant Diseases* (1913, IV, 200).

The seeds—wheat, for example—are finely powdered and extracted with physiological salt solution. The filtered extract is then injected, in small quantities at intervals of three to ten days, into a small animal. After a suitable period the blood serum of this animal is separated and filtered, and the filtrate tested with a few drops of an extract of the seeds under examination. If these are of the same kind as the original seed a precipitate will be produced, whereas the liquid will remain clear on the addition of extracts from other kinds of seeds.

By this method Relander obtained a precipitate on adding extracts of two-rowed barley to the serum of a rabbit which had been treated with a similar extract, whereas no precipitate was obtained with extracts of six-rowed barley. In the same way it was found possible to distinguish between American, Italian, and Norwegian clover seeds, but Finnish seed reäcted in the same manner as Norwegian seed.

By means of this test it should be practicable to distinguish, prior to cultivation, between awned and awnless varieties of wheat, which has hitherto been impossible.

CARBON TETRA-IODIDE.—An iodide of carbon, CI_4, which crystallises in ruby-red octahedra, having a specific gravity of 4·50 at 0° C. was first obtained in 1885 by the action of iodides upon organic chlorine compounds. The various reäctions by which the tetra-iodide may be prepared have recently been studied by M. Lantenois (*Comptes Rendus*, 1913, CLVI, 1385). In order to avoid decomposition of the product it is necessary not to let the temperature exceed 92° C., and the most satisfactory results have been obtained by heating lithium chloride for five days at that temperature with an excess of carbon tetrachloride in a sealed tube. A pure product could also be prepared by treating iodoform with a hypochlorite.

XUM

THE TESTING OF DISINFECTANTS.—The usual method of testing the value of disinfectants is by comparing their germicidal powers under standard conditions. This test, which is commonly known as the Rideal-Walker test, has recently been subjected to severe criticism by Messrs. Kingzett and Woodcock (*Analyst*, 1913, XXXVIII, 190), who cite the results of experiments to show that the conclusions afforded by the method are fallacious. For example, they point out that such powerful chemical agents as nicotine, prussic acid, and strychnine have little or no action upon the typhoid bacillus, and that corrosive sublimate has a much lower value than many coal-tar preparations when tested by the bacteriological method. Again, copper sulphate, which is known to possess germicidal powers, appears in the light of this test to be nearly inert. In the opinion of these chemists the Rideal-Walker test does not take into account variations in the chemical conditions, and they consider that the only reliable method of examining disinfectants as a class is to test them for the particular purposes for which they are required. At the same time they consider that there is no doubt that for coal-tar disinfectants the Rideal-Walker test is the best that has yet been devised.

GEOGRAPHY.

By A. STEVENS, M.A., B.Sc.

TOPOGRAPHY, EARTH-MOVEMENTS AND ISOSTASY.—In 1909 the United States Coast and Geodetic Survey began publication of a series of bulletins* on Isostasy and the "Anomalies of Gravity," which may be said to develop along one line the work begun by Bouguer at Chimborazo, and Maskelyne at Schiehallion. The possibilities of the principle of isostasy in accounting, in part at least, for the configuration of the land surface of the globe have been for some time generally, if darkly, seen. But recently the subject has been more closely studied, and interesting accurate determinations have been made by Americans of the degree to which isostasy obtains, and of the amount of correspondence between anisostatic conditions and the irregularities of the terrestrial surface.

In these official publications isostasy was defined, a convenient and approximately correct upper limit of isostatic equilibrium fixed relative to sea-level, and accurate determinations in dynes of the actual intensity of gravity given for upwards of a hundred and twenty stations in the United States. For these stations theoretical values of the intensity were computed by three methods: that of Bouguer, the free-air method, and a new method due to Hayford, corrections being applied for topography and compensation. The deficiency or excess of the observed value over this computed value of the intensity is called the "anomaly of gravity" for the station. The United States have been mapped in areas of deficient or excessive gravity intensity, and the rate of variation shown by contouring.

As elsewhere, in the United States there is evidence of differential vertical movement in the crust of the earth. In particular the terracing of the Atlantic continental slope, the submarine canyons and valleys indenting the Atlantic and Pacific coasts, and the Post-Glacial deformation of the raised beaches of the great lakes demonstrate extensive subsidence. Deep valleys cut in the Tertiary deposits of Louisiana to depths of between two and three thousand feet, which have been filled with material containing shells representing living species only, prove recent subsidence at the coast to the extent of two thousand three hundred feet, increasing inland, it is estimated, to three thousand feet.

Post-Glacial deformation has frequently been ascribed to the tendency towards isostatic equilibrium asserting itself on the disappearance of the ice. J. W. Spencer† uses the anomalies of gravity to show the inadequacy of the weight of the ice-cap to counterbalance the earth-pressures involved. Gravity anomalies are worked out by means of constants, due to Bowie, to equivalent rock-thicknesses, and between the figures so obtained and the amounts of subsidence and distortion remarkable correspondence is observed.

Spencer attributes the topographical "bulges" to differential sinking conditioned by crustal rigidity, and invokes as the prime cause of movement shrinkage of the earth beneath the oceans and continents. Thereby continents are raised and then gradually they sink towards isostatic conditions, preserving on their submerged borders the marks of the denudation they suffered in the elevated condition. This explanation, of course, in itself presents little that is new, and possibly may require revision in the light of work in other fields of research. But it is important that a definite and quantitative study of some topographic questions has been found possible and initiated. Further work, of which we have a promise, will be looked for with interest.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

AUSTRALITES.—The curious little bodies of volcanic glass found scattered throughout Australia, and known as australites, are the subject of a memoir by E. J. Dunn (*Bulletin No. 27, Geological Survey of Victoria*). These bodies are mostly button-shaped, with a central core and depressed rim. The latter occurs only in the more perfect forms owing to the accidents of weathering. These discoidal forms are by far the most abundant; rarer shapes are elongated cylindrical and dumb-bell shaped; others are quite irregular. The material of the australites is acid volcanic glass, identical in structure and composition with obsidian. Thin sections show that the australites have good flow-structures, and have been built up by material which flowed in from above and around their peripheries.

These bodies are regarded by Mr. Dunn as the blebs or lower portions of glass bubbles. They are very similar in form to the drop of water which collects at the base of a soap-bubble. They are conjectured to have been formed in volcanoes, and their distribution over Australia is accounted for by their dispersal through the agency of air-currents. The bubbles would be blown up to a height of five or six miles above the volcano, and before their destruction might have been carried hundreds of miles from their point of origin by the air-currents of the upper atmosphere. On the bursting of the bubbles the pendant blebs would fall to the ground, and would become embedded in whatever formation was then in process of deposition.

Australites occur in deposits representing a period corresponding with that covered by the last great episode of volcanic activity in Australia. It is uncertain, however, how far they extend back into the Tertiary era. They were formerly regarded as of meteoritic origin; but this cannot be reconciled with their chemical composition, which is utterly unlike that of any meteoritic body, with their symmetrical shapes, and local distribution.

* J. F. Hayford, "The Figure of the Earth and Isostasy from Measurements in the United States"; "A Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy" (*U.S.C. & G. Survey*, 1909); J. F. Hayford and W. Bowie, "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity"; W. Bowie, "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity, Second Paper" (*U.S.C. & G. Survey*, 1912).

† J. W. Spencer, "Relationship between Terrestrial Gravity and Observed Earth Movements in Eastern America," *Amer. Jour. Science*, June, 1913.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

"THE DOCTOR."—At the June meeting of the Royal Meteorological Society a paper by Mr. H. W. Braby was read on the Harmattan Wind of the Guinea Coast, which was based upon the results of five years' observations made at Zungeru, in Northern Nigeria. The harmattan blows during the winter months along the coast of Upper Guinea, from French Guinea to the Cameroons. It is exceedingly dry and brings with it fine sand which enters the crevices of doors and windows, covering everything with a film of dust. The sun is partially obscured, and distant objects become invisible. It blows intermittently from November to March, and is, generally speaking, health-giving, although its extreme dryness is trying to new residents. It is locally known as "the doctor."

The harmattan almost invariably blows from the north-east, a circumstance which justifies the presence of dust particles brought from the Sahara. In some respects the wind partakes of the nature of a Föhn. It is exceedingly dry and blows from elevated to lower regions. Mr. Braby points out that its direction necessitates there being an area of high barometric pressure to the north and of low pressure to the south. The area around the northern tropic, however, seems scarcely far enough from the equatorial regions to be the seat of a well-defined winter anticyclonic system, such as prevails in the interior of Asia at that season. The equatorial low-pressure belt is, however, now at its southern limit, and this combined with the somewhat lower winter pressure to the north appears to be sufficient to establish a north-easterly wind along the Guinea Coast.

HURRICANES OF THE WEST INDIES.—The opening of the Panama Canal in the near future will no doubt bring about a change in the long-established sailing routes and turn much of the tide of commerce of the Atlantic and the Pacific towards the Isthmus of Panama. The convergence of new routes to the Caribbean Sea and the Gulf of Mexico will necessitate the crossing of a wide area swept at intervals during several months of the year by the severest type of storm known to the mariner, viz., the West India hurricane. With the view of giving information on this subject Professor O. L. Fassig has tracked all the hurricanes which have occurred in the West Indies during the thirty-five years 1876–1910, and the results have been printed in a bulletin published by the U.S. Weather Bureau.

The hurricane belt may be defined as the area embracing the Caribbean Sea, the Gulf of Mexico, and the West India Islands. Within this area the points of origin are distributed with a fair degree of uniformity, although belts of varying frequency are clearly discernible. There is a well-marked main path of greatest frequency through the northern half of the Caribbean Sea, extending almost due east to west between the Windward Islands and Jamaica; taking a north-west crossing through the Yukatan Channel and across the western end of Cuba, the path recurves in the eastern portion of the Gulf of Mexico and across the Florida Peninsula into the North Atlantic, with a north to north-east trend. There is a secondary path, not so well defined, extending from the northern group of the Windward Islands in a west-north-west direction across the Bahama Islands and recurving east of Florida in the North Atlantic Ocean. Between these two paths lie the Greater Antilles—Cuba, Jamaica, Haiti, and Porto Rico. Of these islands Porto Rico and Haiti are comparatively free from the devastating winds near the hurricane centres; the western half of Cuba is crossed in the recurve of a large percentage of the storms of the Caribbean Sea, or those of the main branch referred to above. These two paths coincide very closely with the two branches of the great equatorial current of the North Atlantic Ocean, the main stream of which passes through the Caribbean Sea and the Yukatan Channel into the Gulf of Mexico and out into the Atlantic again through the narrow channel between Havana and Key West. Here it meets the northern branch of the equatorial current, which is more in the nature of a wide surface drift of equatorial waters passing through the Bahama group of islands, forming, later in its course, the eastern portion of the Gulf Stream.

The normal track of hurricanes for the entire season resembles a parabola in form. The first branch extends in a direction west by north, between the parallels of 18° and 20° N. lat., to the centre of the hurricane area (23° N. and 70° W.), then north-westward and north; recurving over Central Florida, the trend is north-eastward over the Atlantic along the second branch of the parabola.

The geographical centre of origin for the entire season is just off the north-west coast of Haiti. The average point of recurve is in the centre of the Florida Peninsula. The advance of the season is marked by a slight increase in the latitude of the point of recurve. The movement of hurricane paths from south to north and return southward coincides very closely with the movement of the trades and the equatorial belt of calms.

Conditions favourable for the formation of hurricanes in the West Indies begin in the month of June, but do not become well developed until the month of August. From August to the close of October is the real period for these storms. The mean daily movement of hurricanes for the entire season is about three hundred miles, or about 12·5 miles per hour. After passing the recurve there is a considerable increase in the velocity, especially in the latter part of the season. The average period of duration of hurricanes while within the zone below the latitude of 30° N. is about six days; about three days are spent in moving westward along the storm's path and two days in the recurve. After the recurve the storm enters into the region of temperate zone cyclones, and may continue its existence for many days, sometimes crossing the entire expanse of the North Atlantic and even into Europe.

HURRICANE, TYPHOON, AND CYCLONE.—These terms are applied to the same type of storm, but, as Mr. O. L. Fassig has pointed out in the paper quoted above, they are the same in essential character. To the meteorologist they are all "cyclones" or storms in which the surface winds blow toward a central area of low barometric pressure at angles varying between 0° and 90°. This broad definition includes not only the intense storms of the Indian Ocean and the Bay of Bengal, originally called "cyclones," the hurricanes of the West Indies, and the typhoons of the Pacific, but also the temperate-region storms usually referred to as "barometric depressions," "storm areas," or simply "lows," and the tornadoes of central valleys of the U.S.A., and waterspouts over the seas in all parts of the world. In all storms of this class the surface winds blow more or less spirally inward toward an area of minimum atmospheric pressure, then upward and outward at elevations varying with the extent and intensity of the storm. The term "hurricane" is restricted to cyclones which have their origin and field of action within well-defined limits, embracing the West Indies and neighbouring waters of the North Atlantic. The storms occurring in tropical regions of the Western Pacific are called "typhoons." In the Indian Ocean they retain the name originally given them by the early English mariners, namely, cyclones. It is only in comparatively recent years that the term "cyclone" was given the broader, and at the same time more technical, definition to include all so-called "revolving" storms. The temperate-region cyclone covers a greater area than the tropical variety, the diameter of a well-developed storm of the middle latitudes being over one thousand miles, and occasionally covering more than half the area of the United States; the cyclone of the tropics is generally not over three hundred to four hundred miles in cross-section, but probably penetrates to a greater height into the atmosphere than the extra-tropical cyclone. Tropical storms are accompanied by a greater fall in the barometer, resulting in more destructive winds and heavier rainfall than in the temperate-region cyclone, where the barometer falls with a more uniform gradient from the

XUM

edge of the storm to the centre. In the tropical storm there is a moderate decrease of pressure to within forty or fifty miles of the centre, and then a rapid fall, which in exceptional cases may descend to twenty-eight inches and even less. This steep-pressure gradient marks the area of the destructive winds and the excessively heavy rainfall which are characteristics of the tropical storm.

CLIMATE AND HEALTH.—During last session Mr. W. Marriott read a paper on "Meteorology and Public Health" before the Institute of Sanitary Engineers, which has now been published in their Journal. He showed that a bracing climate is invigorating and acts as a tonic to the body. This is due to an open exposure and a good wind or current of air blowing over the place. This continuous flow of air over the body removes the moisture from the skin, and so causes a lowering of the temperature, which in turn produces a crisp and pleasant feeling. A relaxing climate, on the other hand, is enervating and causes a languid feeling. This is largely due to the situation being sheltered, and also to comparatively little movement of the air. Consequently the moisture from the skin is not so freely removed as when there is a continuous flow of air. Again, there is the inland climate and also the sea-coast or maritime climate. Inland the temperature, as a rule, is high during the day and low during the night, and so there is a considerable diurnal range of temperature. Along the sea-coast the temperature does not rise so high during the day nor fall so low during the night; consequently the range of temperature is less on the coast than it is inland.

Extremes of temperature—hot weather in summer and frost in winter—cause an increase in the death-rate. In summer the increase in the number of deaths is due almost entirely to cases of infantile diarrhoea. In winter the increase in the number of deaths is due almost entirely to diseases of the respiratory organs, especially among young children and old people.

Pneumonia and bronchitis are most prevalent in the colder months, and generally follow cold, damp weather with marked changes of temperature, which lower the vitality and are conducive to chills. Severe cold spells are likely to be followed by an increase of pneumonia, especially among elderly persons and children.

MICROSCOPY.

By F.R.M.S.

THE APLANATIC AND ACHROMATIC CONDENSER AND ITS USE AS AN APERTOMETER.—The Aplanatic and Achromatic Condenser possesses another useful quality, inasmuch as it can be employed as an apertometer. This property arises from the following optical facts. The iris-diaphragm being situated near the lower focal plane of the condenser, an image of it is formed thereby at a distance which may be equated at infinity. Of this image the objective forms another at its posterior focus and situated near the outer surface of the back lens on the side towards the eyepiece. The rays of a pencil of light entering the condenser in a direction parallel to its axis intersect at its anterior focus. As this is made to coincide approximately with the lower principal focus of the objective it follows that the pencil of rays which proceeds from the focus of the objective will emerge from its posterior focal plane in the form of a pencil composed of approximately parallel rays.

FIGURE 339.

The base of the pencil of rays appears on the back lens of the objective as a bright circle, and hence it will be seen that this bright circle of light and the image of the iris-diaphragm are situated more or less in the same plane. The diameter of the circle of light is governed by the aperture of the objective which corresponds to an equal angular aperture of the condenser. The latter again is determined by the opening of the iris-diaphragm. The aperture of the condenser can be computed from the diameter of the iris-diaphragm, thus supplying the requisite datum for determining the aperture of the objective.

That the condenser may be used in this way as an apertometer is due to the fact that its formula satisfies the sine condition, and not so much to its spherical and chromatic correction, the principal effect of the latter being that the condenser furnishes a more sharply defined image than an ordinary condenser.

The sine condition is expressed by the formula $\frac{h}{\sin e\,\alpha} = \text{const.}$

In the case of parallel incident light this constant quantity is numerically equal to the focal length of the condenser, h is the semi-aperture of the iris-diaphragm, whilst $\sin\alpha$ with dry lenses and $\mu \sin\alpha$ with immersion lenses represents the numerical aperture of the condenser. From this it will be seen that the aperture of the condenser varies directly as the numerical aperture of the condenser as well as that of the objective. This simple relation is a convenient circumstance, inasmuch as the indices corresponding to the numerical apertures 0·1, 0·2 . . . to 1·3 are separated by uniform intervals (see Figure 339).

To calculate and register the scale of apertures become under these circumstances a very simple matter. When a preparation lies between the objective and the condenser the angle by which the rays emerge from the condenser is the same as that by which they enter the objective; that is to say, the angles which determine the aperture of the condenser and objective remain equal, since the object slide, the cover-glass, and the interval between the latter and the objective behave optically as plane and parallel plates. This being so, the angles of incidence and emergence of a ray passing through the intervening media are identical so long as the surrounding media—in this case air, water, or oil—remain the same.

The aperture may be determined in the following manner:—Focus the objective in the usual manner in the plane of the object, using diffused light; next remove the eyepiece and, placing the eye immediately above the tube, view the circle of light at the back of the objective and open the iris-diaphragm, the image of which will also be seen in this plane, until its opening just coincides with the boundary of the circle of light at the back of the objective. To use the condenser in this way it is necessary to have the mount of the iris-diaphragm graduated in terms of the numerical apertures.

It will be admitted that it would be difficult to imagine a simpler and more inexpensive device for measuring the aperture of lenses, and the manner of using it cannot give the slightest difficulty. The accuracy of the results is all that could possibly be desired for any practical purpose. The difference in the aperture of objectives, as found by this simple method, and its absolute value, as determined by the most exacting methods in use, is too insignificant to disclose any appreciable difference in the light-transmitting and resolving power of objectives differing to this small extent in their apertures. As a matter of fact, these discrepancies are no greater than those unavoidable and invariably existing differences in the individual objectives of the same denomination arising from slight variations in the thickness, position, and mounts of the lenses.

It is no doubt convenient to be able to determine without trouble and with practically a sufficient degree of accuracy the aperture of an objective. This, however, is scarcely the best use to which an apertometer can be put, as it is a far more important advantage that the apparatus enables the observer at any instant to ascertain and state numerically the aperture of direct light at which he is actually working, and that will give him the best results.

The reader need scarcely be reminded of the importance of the proper choice of the aperture of the condenser, and to realise how different are the effects produced by the different apertures one need only instance the case of Koch's structural and colour images: both are the result of the same optical condition—in one case with a contracted diaphragm to attempt to bring out fine structural details in unstained preparations, in the other with the condenser opened to its full extent to show deeply stained bacteria.

A condenser whose aperture can be varied in a numerically definite manner does away with loose statements to the effect that this or that investigation should be carried out with the condenser shut down to one third, a half, two thirds, and so on. Directions of this kind are far too indefinite, and are not even applicable to condensers of different maximum apertures. In future it will be as easy as it will be desirable to specify the aperture of the condenser among the other particulars relating to microscopic observations, projection, and photomicrography. such as the denomination of the lens, its magnification, and the nature of the illumination, time of exposure, and so on. This will be an easy matter, as the aperture can be read by the index of the iris-diaphragm.

C. METZ. (*Wetzler.*)

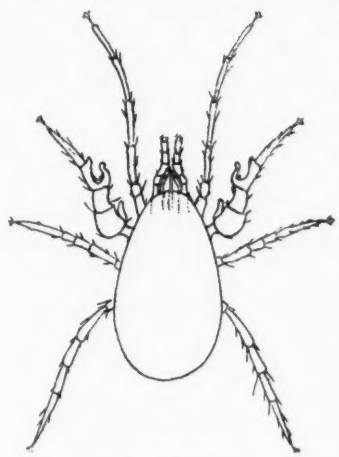

FIGURE 340.

Gamasus equestris Koch.

Drawn under camera lucida from a specimen found at Barmouth. ♂

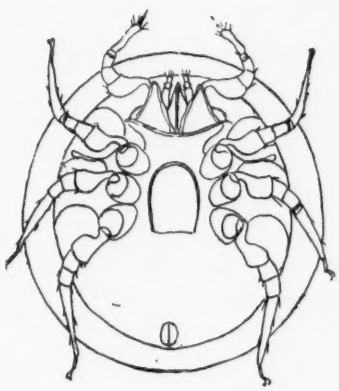

FIGURE 341.

Uropodidae.

Drawn from a specimen found in moss at Sunningdale. Ventral surface of *Cilliba cassidens*. ♀

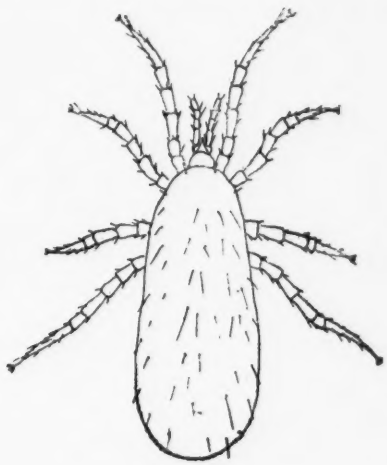

FIGURE 342.

Dermanyssus avium.

Drawn under camera lucida from a specimen from a canary.

GAMASOIDEA.—Another neglected super-family of mites is the Gamasoidea, and yet entomologists are continually coming across specimens, either as messmates or parasites, on various kinds of insects. Not much notice, however, is taken of them. They are more often than not thrown away as a nuisance; yet they may be more interesting than their host. The most commonly known of all the Gamasids is no doubt *Gamasus coleoptratorum* and *G. crassipes*, so often found in large numbers on the Dor beetle and others. Beetles, however, are not the only insects on which they are found; all other sorts of insects are pressed into their service either to supply them with nourishment or as a means of getting from one place to another. One family of the Gamasoidea—the Dermanyssidae—are all parasitic on warm-blooded animals.

The characteristics of the super-family are—they are without any visible eyes; they are mostly pale coloured: being generally a light brown or fawn colour they have none of the brilliant reds we find in the Trombidiums. The bodies are broad and flat. The skin is mostly smooth and tough, in some species chitinous only in parts, the other parts being thinner and paler in colour. The legs have seven segments, the tarsi has two claws with a caruncle or sucker; this caruncle assumes different forms in different species.

They prefer damp places to live in; that is to say, those that are not parasitic. They are found under stones, decayed wood, garden rubbish, stables, under loose bark of trees, in moss, and I once found a large number in a deserted robin's nest.

The Gamasoidea is divided into three families—Gamasidae, Uropodidae and Dermanyssidae. Nathan Banks, the American writer on mites, gives the following key to the three families of the Gamasoidea:—

(1) Parasitic on vertebrates: mandibles fitted for piercing; body sometimes constricted. Dermanyssidae.

Free, or attached to insects, rarely on vertebrates, never on birds. 2.

(2) First pair of legs inserted within the same body-opening as the oral tube: genital apertures surrounded by the sternum. Uropodidae.

(3) First pair of legs inserted at one side of the mouth opening, male genital aperture usually on the anterior margin of sternal plate. Gamasidae.

The Dermanyssidae are all parasitic. The best-known representative is the red mite, found in such large numbers in bird-cages and fowl-houses that have not been kept clean. This bright red colour of the mite (which is commonly known as *Dermanyssus avium* Dug.) is due to the amount of blood which the mite has sucked from its host during the night. In the daytime, if it can possibly hide away, it is invisible. The Dermanyssidae is split up into about half a dozen genera. There are several papers on this family, but I have not heard of any monograph.

The Uropodidae.—The most striking feature about this family is that some of its members are found attached to their host with a connecting filament which De Geer thought was of the nature of an umbilical cord by which the mite drew its nourishment. Other naturalists thought it was a silken cord with which the Uropoda tied itself to its host to prevent it being brushed off. It has since been found to be connected with the anus of the mite, and to be nothing more or less than its consolidated excrement: this connection the mite can sever at will. Banks says that these mites so attached are not true parasites, but that it is a means used by nymphs as a

XUM

means of migration. This family is divided into about six genera.

The Gamasidae are the largest family of the three, containing about twenty genera. A number of papers have been published in the British Isles on the Gamasoidea in natural history and microscopical journals. Mr. Michael has given two, if not more, very interesting ones on the internal anatomy of Gamasidae and Uropoda; also one on the life-history of Gamasidae, and in 1888 described one new species. Dr. George has also described and recorded some rare and interesting species in *The Naturalist* from time to time—three species in particular, of the genus *Epicrius*. But there is no monograph on any of the three families yet, neither is there a Tierreich.

Figures 340–342 will help to convey the general appearance of each family. But, as Mr. Banks says, the Dermanyssidae and the Gamasidae are so closely allied by structure that the parasitic habits are the best character for separation.

C. D. SOAR, F.L.S., F.R.M.S.

QUEKETT MICROSCOPICAL CLUB.—May 28th.—T. A. O'Donohoe read a paper on "Minute Structure of *Coscinodiscus asteromphalus*, *Pleurosigma angulatum*, and *P. balticum*." The object of the paper was to prove that the "black dot" is the correct image of diatom structure. Photomicrographs, mostly at ×4000, were shown of fragments of the diatoms mentioned. When the edge of the fracture was sharply focused the transparent silex was shown as white and the perforations as black. On slightly raising the objective the silex was rendered as black and the perforations as white. It was therefore thought to be justifiable to relegate the "white dot" images of diatoms to the abode of Mr. Nelson's "ghosts."

June 24th.—E. M. Nelson sent a note describing Koristka's new loup.

H. Sidebottom, contributed a paper on "The *Lagenae* of the South-West Pacific." This is part two of a paper published in the April 1912 issue of the Club *Journal*. There was some discussion as to the significance or use of the very beautiful markings and decorations found in this and other groups of organisms. The President could not conceive it possible that the presence or absence of a minute projection on a sponge spicule, for instance, could make any difference whatever to the organism, especially as in the case of the sponge, the spicule is buried in the general protoplasmic mass of the animal. In the case of foraminifera the markings are invisible during life, as they are concealed under the usual gelatinous mass of exterior protoplasm.

E. M. Nelson described "A new method of measuring the magnifying power of a microscope." The "constant" of an eyepiece with a given tube-length is determined. This "constant" is found by first determining by any of the usual methods the combined magnifying power of that eyepiece on the given tube-length with a medium power objective, such as half-inch. Second, measure the exact diameter of the field by means of a stage micrometer. The product of these two quantities is the "constant" of that eyepiece with the given tube-length. Example—objective one-third of an inch, eyepiece, compensating × 8, tube-length 170 millimetres, measured magnifying power × 280, measured field 0·023 inch, product is 6·44, which is the "constant" of that eyepiece for 170-millimetre tube. The power of any other objective with this eyepiece and tube-length can be determined by measuring the diameter of its field with the stage micrometer. The magnifying power will obviously be the eyepiece "constant" divided by the diameter of the field (an objective of varying power with a negative front cannot be measured in this manner). A number of examples were given. The "constant" may also be employed for ascertaining the total magnification for any tube-length. All other conditions being the same, the total magnification will be proportional to the tube-length used.

PHOTOGRAPHY.

By EDGAR SENIOR.

USE OF GLYCERINE IN DEVELOPING PLATINUM PRINTS.—As mentioned in last month's notes on platinum printing, glycerine is of use in the development of these prints, as when added to the developer it so reduces its rapidity of action as to enable local development to be carried out without any difficulty. As the sensitive salts with which the paper is coated are almost insoluble in glycerine, this may be brushed over the surface of the exposed paper without risk of injury to the print. A mixture of glycerine and developer may then be applied with a brush and an over-printed portion of the subject may be retarded by the application of a weaker developer, or one containing more glycerine, until the other parts of the image are sufficiently strong. This method of treatment lends itself particularly to the production of vignetting effects on account of the great softening of the edges that can be obtained. The strength of the solution employed by different workers varies, but the following will be found to answer well:—

Oxalate of Potash	1 ounce
Water	3 ounces
Glycerine (pure)	1 ounce

This will form a stock solution which for use may be taken in the proportion of one part mixed with an equal volume of water. If preferred, the developing salts may be used in place of the oxalate, as with a little practice it is quite easy to control development with either. When the desired result has been obtained the prints are placed for the required time in each of the three acid baths, and finally washed and dried, intensifying under-exposed platinum prints with gold.

Some years ago Mr. Alfred W. Dolland published a method of strengthening an under-exposed platinum print by means of a solution of gold chloride applied with glycerine. The writer tried this at the time with perfect success. The procedure consists in applying glycerine to the finished print and then spreading a solution of gold chloride by means of a piece of cotton-wool or a brush, the strength of the gold solution which we used being fifteen grains in fifteen drachms of distilled water. The print rapidly gained in strength, assuming a fine bluish-black colour, and when the action had proceeded far enough the print was washed, and an ordinary amidol developer applied for a few minutes in order to reduce any remaining gold chloride to the metallic state, when a final washing completed the operation. We have quite a number of prints that were treated in this manner, which appear as fresh as when first produced, and certainly the colour in many cases produced a more pleasing effect. Platinum prints may also be intensified by a method, due to Baron Hubl, of depositing further platinum upon them. In order to employ this method the following solutions have to be made up:—

A	
Sodium Formate	48 grains
Water	1 ounce
B	
Platinum Tetrachloride	10 grains
Water	1 ounce

For use fifteen minims of each of the above are taken and made up to two ounces by the addition of water. The print is placed in a flat dish and the solution is poured over the dish, which is kept rocking until the desired effect is seen in the print, when the latter is washed and dried.

WARM TONES IN PLATINUM PRINTS.—Various substances have from time to time been recommended as additions to the developer in order to vary the colour of a platinum print, but the one most generally employed is mercuric chloride, as by its means, together with variations in the temperature of the developer, tones ranging from warm black to sepia are readily obtainable. Numerous formulae for

use in the production of these tones have been given, although the following is perhaps as satisfactory as any:—

Mercuric Chloride	3 grains
Potassium Oxalate...	48 „
Potassium Phosphate	48 „
Water	1 ounce

The temperature at which the prints are developed ranges from 65° to 170° F., according as a warm black or one approaching sepia is desired. When warm tones are obtained the gradation is usually much softer than that of a black print from the same negative; there is therefore a tendency to general flatness in some cases. When this is the case the results may often be improved by the addition of about five minims of a two per cent. solution of potassium bichromate to each ounce of developer. As special paper is, however, made by the Platinotype Company and others for obtaining sepia prints, this should be employed, taking special care to protect the same during examination of the printing from the action of weak light as much as possible; and as these prints, unlike the black one, are likely to be affected by light when in the acid baths a more subdued light should be employed during this stage of the operation as well.

SECTOR SHUTTERS.—We have received a copy of a paper read at the Optical Convention on June 20th, 1912, by Cyril F. Lan-Davis, F.R.P.S., on the subject of sector shutters. The author, in dealing with the number of leaves comprised in shutters of this type, and showing that the position of the pivot does not affect the ratio of the total diameter of the shutter to its opening diameter, proceeds to discuss the effect that the shape of the leaves, as well as their number, has on the shutters' efficiency, showing by means of diagrams that an alteration in the form of the leaves as well as a reduction in their number results in an additional area being uncovered for equal partial central openings in the shutter. In doing this comparison is drawn between a ten-leaved shutter of the usual iris form, which opens in an expanding circle from its centre to edge (so that the amount of light transmitted by the margin is very small indeed), and one having two leaves only, which opens in a broad band that rapidly expands to the full circle. A shutter of this kind would also possess the further advantage that it could be made smaller, as the ratio of the total diameter to the aperture is only 2·1. Although shutters of this type are not yet on the market, we believe Messrs. J. H. Dallmeyer, Ltd., are making arrangements for their manufacture. We have received from Messrs. Wratten & Wainwright, Ltd., several of their booklets dealing with the subject of orthochromatic photography and the use of light filters for special purposes, such as photo-micrography, and in the illumination of the dark room. We may mention in connection with our notes in the June issue, dealing with the testing of dark-room light filters, that the firm make quite a number of special screens for this purpose, which are scientifically tested, and may therefore be relied upon to afford a perfectly safe light for use during the manipulation of the particular kind of plate "or sensitive surface" that they are supplied for use with. While reserving any further remarks for some future occasion, we may say that the name of Wratten & Wainwright is always a sufficient guarantee of the excellence of any product issued by them.

PHYSICS.

By ALFRED C. EGERTON, B.Sc.

X_3?—Professor Sir J. J. Thomson, O.M., gave the Bakerian Lecture to the Royal Society on May 22nd. In the course of an account of his recent experiments, he surmised that a gas exists, which he terms, somewhat mysteriously, X_3. When the positive rays are allowed to stream back through the hole in a hollow cylindrical cathode in a vacuum tube, through which an electric discharge is passed, they ionise the gas through which they pass. The rays produce a number of differently electrified gas particles; they give rise to:—

(i) Atoms with one unit positive charge of electricity,
(ii) Molecules with one unit positive charge,
(iii) Multiple charged atoms,
(iv) Atoms with one negative charge,
(v) Molecules with one negative charge,

and when the discharge is passed through air at very low pressure, since oxygen, nitrogen, argon, carbon monoxide and carbon dioxide, and hydrogen (from water vapour) are present, and each of them may be split up in the above ways, the character of the gas evidently becomes somewhat complicated. Nevertheless, by submitting the gas to magnetic and electric fields, the charged particles can be identified from the position they occupy on a suitably placed screen or photographic plate, when fields of known strength are applied; their mass can then be calculated. By such means there is found in the gas of tubes in which cathode rays are allowed to bombard against solids, particles which consist either of carbon with four charges of electricity or a substance of atomic weight 3 with a single charge—this latter is the substance to which Sir J. J. Thomson assigns the name X_3, because it has not itself been isolated yet in the free state, and because it should have atomic weight 3. The reasons given for considering that it is not carbon with four charges are that it can pass over red-hot copper oxide and then over potash without being absorbed, it is not changed when sparked with excess of oxygen, it can pass over metallic sodium, it is not condensed by liquid air, but is absorbed by charcoal cooled with liquid air, while it combines with mercury vapour in presence of the electric discharge, and also to some extent with red-hot copper.

It will be very interesting if this gas can be caught and examined; a new gas a little heavier than hydrogen and lighter than helium may explain much that is not yet understood.

NOMENCLATURE OF RADIOACTIVE SUBSTANCES. — A little while back an international committee assembled in order to discuss matters connected with radioactivity; one question was the standardisation of radioactive substances, and in order to be able to refer such substances to a definite standard it was settled that Mme. Curie should prepare a solution containing a known amount of pure radium, the unit of radioactivity so obtained being called a "curie." Another question was the nomenclature of radioactive substances; there are three main groups of radioactive substances—the radium, the thorium, and the actinium series. Hitherto, as the separate products of these three series have been discovered, it has been usual to distinguish them by consecutive letters of the alphabet, but sometimes when such names have been settled a product is subsequently found which lies between two such consecutive letters, *e.g.*, thorium C_1 and C_2. The question of the nomenclature of these many products was therefore postponed till such a time as it should become certain that no more intermediate products are present to be discovered. However, it is unsatisfactory that the matter was left in so chaotic a state as it is at present; for in different journals, or indeed often in the same paper, the same product is given more than one name.

There are two ways open—either each product should be given a definite name as is the custom is for the ordinary elements, or some elastic system should be devised which would not only allow for the discovery of new products, but would also give an idea of the properties of the separate products. The former system has been favoured by Sir William Ramsay in naming radium emanation "niton," Professor N. Campbell has advocated the other way.

In chemistry organic compounds are named in such a way that the chemist can tell from the name of the substance many of its properties, and also its relationships with other substances; for instance, α naphthylamine signifies that the substance contains an NH_2 group in a particular position in the naphthalene molecule. It should be possible to devise a system of nomenclature of radioactive substances from which it would be possible to tell the main properties of the substance. The nature of the rays should be prefixed to the

XUM

name, the number of the product in its series should be included (for knowing this and the rays given by the product, the position of the element in the periodic table, and hence its chemical properties, would be known), and the series to which the product belongs should be the root of the name. It is probable that most of the changes, which give off α or β rays, have now been discovered, and in order to allow for rayless changes where there is no change of mass of the atom but only a difference in configuration the method used in organic chemistry to describe different isomerides (ortho, meta, and para, and so on) might be imitated.

It is to be hoped that before long the radioactive substances will be satisfactorily named.

THE MERCURY VAPOUR LAMP.—The Cooper Hewitt mercury vapour lamp has been so improved that the great objection, viz., the peculiar colour of the light, can now be overcome. The inventor has succeeded in this by placing a celluloid film stained with rhodamine behind the mercury vapour which is giving out light. The rhodamine fluoresces with a red colour, that is to say, the rhodamine is so stimulated by the violet radiations of the mercury vapour that it gives out rays of its own, which are most intense in the red. The resulting luminosity makes a fairly good imitation of daylight.

Professor Wood has noticed that when such a stained fluorescent film is backed by white paper or porcelain the luminosity is much greater than when backed by a silvered surface, the reason being that only part of the fluorescent radiation emerges from the film: the rest is internally reflected and does not get out, unless a scattering reflector, such as a matt white surface, is placed behind. The effect is somewhat striking, and a considerable loss of fluorescent radiation is shown often to occur owing to internal reflection.

The "neon" light, devised by M. Claude, which has the similar advantage of the mercury vapour lamp in being very economical of current, also has the disadvantage of giving rise to a light deficient in certain colours; the light is rich in red, but deficient in green and violet. M. Claude has been able to combine his lamp with the mercury vapour lamp and overcomes this difficulty. The mercury vapour lamp works with a low voltage current, while the neon light is worked by a current of high voltage and frequency. All the same, M. Claude has succeeded in his most recent type of lamp in combining the two quite satisfactorily.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

RESPIRATION IN THE WATER BOATMAN.—A careful study of the process of respiration in this well-known insect (*Notonecta*), which rows on the surface of the water, has convinced Frank Brocher that in ordinary circumstances, at the surface, only the seventh abdominal stigmata are used, both for inspiration and expiration. When the water boatman has finished taking in air, and is about to dive, it makes more energetic expirations, and expels by all its stigmata the excess of air which it has in its tracheal system. This expelled air spreads round the body, to which a portion remains adherent, while another portion returns to the atmosphere or is entangled in bubbles about the abdomen.

THE CIGARETTE BEETLE.—Mr. Charles R. Jones has made an important study of the cigarette beetle (*Lasioderma serricorne*) in the Philippine Islands. It has been prominent for many years as a destroyer of stored vegetable products, and is one of the worst pests of the tobacco industry. All the principal tropical and subtropical tobacco-producing districts abound with it. The eggs are laid in small folds in the dried tobacco, *e.g.*, within the open tip of the cigar or cigarette, or under the overlapping edges of the wrapper. The larva, which is less than a millimetre in length to begin with, eats small cylindrical galleries in the tobacco, especially in the higher-grade tobacco. There is a little Clerid beetle which feeds ravenously, both in its larval and adult stages, upon the larvae and pupae of the cigarette beetles, and acts as a useful check. It has been shown by careful experiments that the cigarette bettle can be absolutely controlled, without affecting the tobacco, by fumigations of carbon bisulphide and hydrocyanic gas, and by using high and low temperatures.

FUNCTIONAL TEETH IN UPPER JAW OF SPERM WHALE.—It has been regarded as one of the characteristics of the Physeteridae—the sperm whale or Cachalot family—that functional teeth are confined to the lower jaw. In the sperm whale, indeed, it is well known that numerous rudimentary teeth occur in the upper jaw; but these have been held to be relatively small, embedded in the gum so that they do not reach the surface, and necessarily, therefore, altogether functionless. It is recorded, however, by Messrs. James Ritchie and A. J. H. Edwards that two out of seven specimens examined at Bunaveneader in Harris bore visible exposed teeth in the upper jaw. They lay in a row along a well-defined groove running the length of the jaw on the inner side of the depressions caused by the mandibular teeth. There were about a score, each eleven centimetres long, all but the tip embedded in the gum, far removed from the maxillary bones. The worn and scratched surface afforded proof of actual use.

LARGEST AND STATELIEST OF BRITISH COELENTERATA.—These words are applied by Professor Herdman to the giant sea-pen, *Funiculina quadrangularis*, which occurs abundantly in certain limited localities on the west coast of Scotland. There appear to be "forests" of them—flexible unbranched colonies fixed in the mud and rising gracefully into the water. The finest specimen obtained in 1912 was sixty-two inches in height, and several were about five feet. Sir Wyville Thomson referred long ago to their "pale lilac phosphorescence"; Professor Herdman notes their "pale translucent rosy tint."

SOLAR DISTURBANCES DURING JUNE, 1913.

By FRANK C. DENNETT.

THERE is very little to record by way of disturbance on the Sun during June, notwithstanding that the disc has been telescopically examined every day. The falling off of activity has been as marked as that at the beginning of 1912.

On the 1st, 4th and 8th there were traces of tiny dark spots, but these were not sufficiently evident to have their positions measured.

Even faculae have been comparatively few and far between. On the 4th, minute faculae were visible within a few degrees of both the South and North Poles. On the 14th a small facula was situated Longitude 69° and Latitude 23° N., therefore approaching the North-Western limb. There was a pale faculic patch on the 28th in Longitude 245°, Latitude 29° S., and so nearing the South-Western limb. Other pale faculae were seen North-East on the 4th, 5th, 7th and 8th; South-West on the 8th; South-East on the 7th and 8th; and near the centre of the disc on the 4th and 5th.

Whilst looking at the projected image of the Sun upon the focusing ground glass of the 4-inch photo-heliograph, formerly in use at Greenwich Observatory, when only one small spotlet was visible, a visitor was heard to remark that he was unaware the Sun ever had so few spots as one. But frequently of late the disc has presented a complete blank. By the kindness of the Astronomer-Royal we are enabled to reproduce a print from the original negative of the Sun taken at the Cape of Good Hope on the morning of April 22nd, 1913, when the disc was devoid of all disturbance except a very small group of faculae near the N.E. limb (see Figure 343 and Figure 344 given for comparison).

The observers were Messrs. J. McHarg, A.A.Buss, E. E. Peacock, J. C. Simpson and F. C. Dennett.

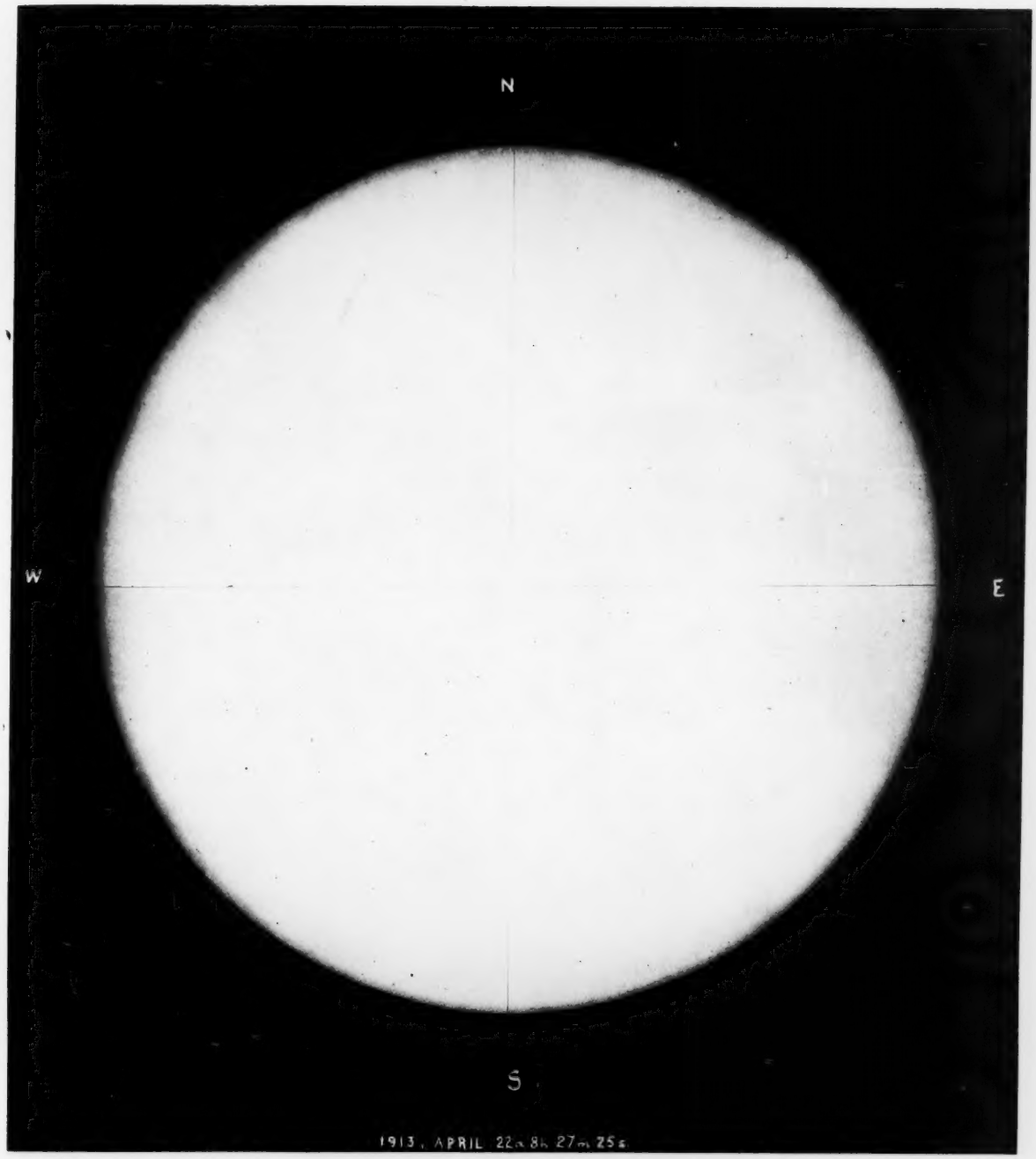

FIGURE 343.

The Sun practically devoid of all disturbance.

Reproduced by the kindness of the Astronomer-Royal from a print from the original negative of a photograph taken at the Cape of Good Hope on the morning of April 22nd, 1913.

XUM

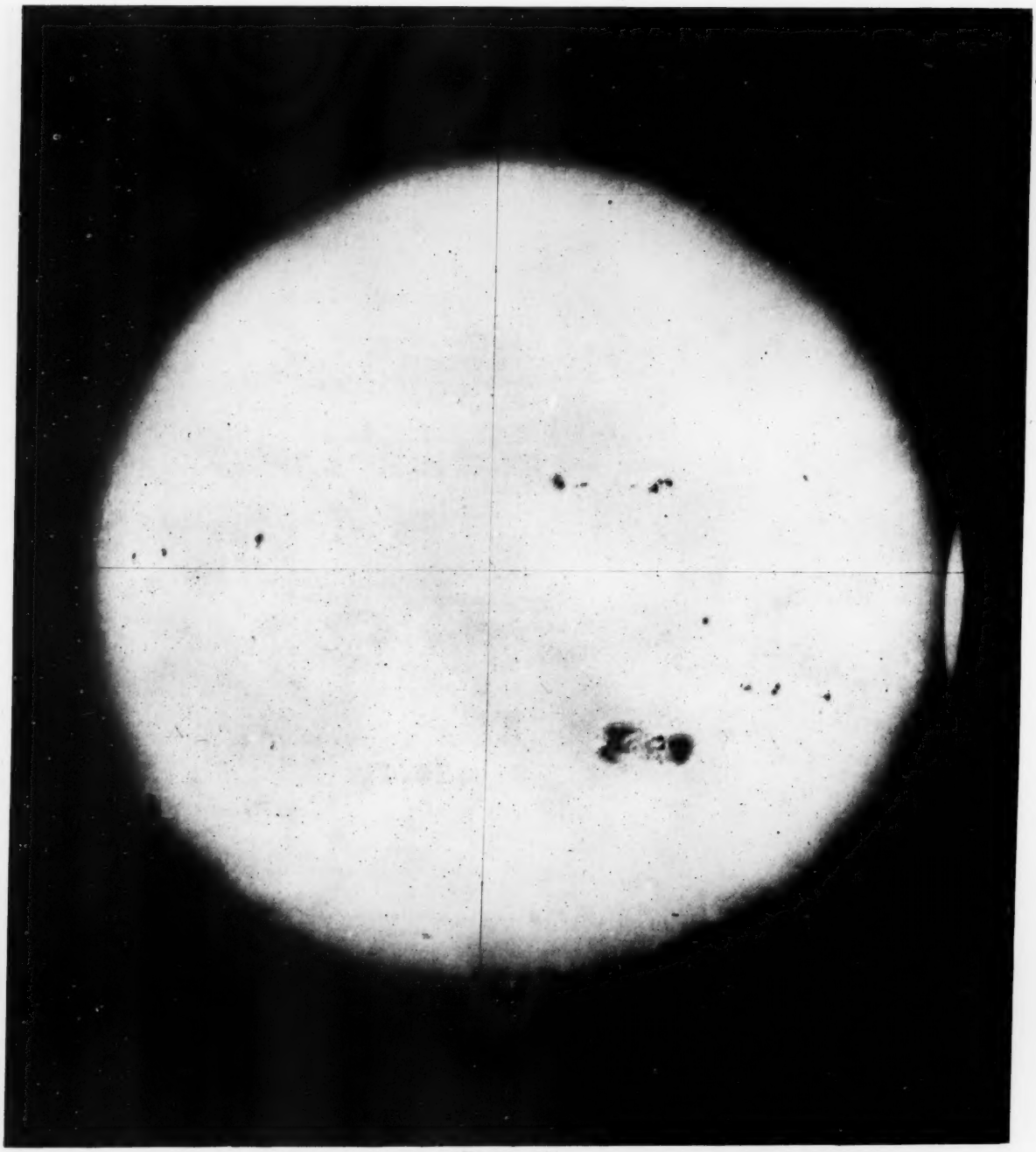

FIGURE 344.

A greatly disturbed Sun.

The Astronomer-Royal has kindly permitted us to reproduce the photograph of the Sun taken on August 8th, 1893, only a short time before the maximum activity. The great spot group is over 100,000 miles at its greatest diameter, and the longer group on the other side of the equator nearly 130,000 miles in length. This picture presents a striking contrast to Figure 343.

XUM

PLANT PROTECTION.*

OF the numerous crusades that are being carried on against the different evils that are recognised as rife to-day, such as the killing of birds for plumage, the inhumane slaughter of animals, the preservation of ancient buildings, and so on, none are of more importance than the one directed towards the preservation of wild plants.

The man in the street thinks, when he reads in the press that a hawker has been fined for selling ferns that have been carted wholesale from the woods and lanes, that that is the only cause of the extermination of beautiful wild flowers and ferns from the outskirts of large towns, spots that, maybe, he has known in his youth as a veritable paradise.

But though this is a prevalent notion it is far from being the truth, and, as everyone knows, a half-truth is often worse than a lie. The publications cited show that there are numerous and widespread other causes at work, some, such as smoke, tree-felling, golf-links—to mention only a few—equally powerful in exterminating plants. Mr. Horwood has collected information on a systematic plan from every county in the British Isles, and is able to point to some sixty causes at work in diminishing plants in particular spots or exterminating them entirely.

As Recorder of the Plant Protection Section of the Selborne Society (with Dr. Rendle as Chairman, and an influential Committee), Mr. Horwood describes the work of that body already accomplished since its formation in 1910. Not least in this direction is the publication of the leaflets† issued to the public and to schools, endeavouring to prevent over-collecting owing to nature study, or by the public in general. Fifty thousand leaflets were issued alone to the schools. The object of the Section is to create a public opinion in favour of a better treatment of wild flowers. None will gainsay the need of this.

It is further desired to achieve certain definite means of protecting plants or obtaining reservations by the help of county councils, rural district councils, landowners, and scientific societies. The last have recently been appealed to, and a fair measure of success has apparently been obtained; but it is desirable that all societies should support so worthy an object by the appointment of a corresponding secretary to assist the Section in its work. In a short notice of so important a matter as this it is impossible to state, more than briefly, the ideals of those who have set themselves the uphill task of obtaining what in Prussia is known as State protection. To the few, probably, this would be distasteful, as implying more officials and the intrusion of bureaucratic methods in scientific affairs; but without the machinery of the State, in the absence of an active and generous public support, there is apparently no present medium for enforcing what is certainly the public opinion in this matter—that is, a determination to prohibit premeditated vandalism, or, what is as bad, careless extermination from want of foresight or knowledge.

The general adoption by all county councils of the principle of obtaining a local order for prohibiting hawking on public highways would, we think, come to much the same thing as a Wild Flowers Protection Act, if, in addition, private lands could by a consensus of assent on the part of all the great landowners be protected by the framing of rules relating to private property.

In the meantime the work of this Section, which Mr. Horwood describes, should have the support of all who feel strongly about this matter. They can, moreover, we may be permitted to say, by obtaining copies of the leaflets cited, do much good in their own districts in their own way by distributing them and remonstrating on every possible occasion with those who are guilty of vandalism. And there is no doubt that any suggestions of a useful nature, or actual cases of extinction or diminution coming within the individual experience of readers of "KNOWLEDGE," that may be sent to him will be welcomed by the author of these cogent appeals as additional evidence in support of this movement for the public good.

* "The Protection of Wild Plants" (Selborne Society, Special Leaflet No. 1); "An Appeal to Nature Study Teachers" (*Ibid.*, Special Leaflet No. 2); "To the Public" (*Ibid.*, Special Leaflet No. 3); "The Need for State Protection of Wild Plants," *Westminster Gazette*, March, 1913; "The State Protection of Wild Plants," *Science Progress*, April, 1913; "The Preservation of our Wild Plants," *School Nature Study*, June, 1913. A. R. Horwood (Leicester Museum), Recorder, Plant Protection Section, Selborne Society.

† These can be obtained from the Secretary, 42, Bloomsbury Square, London, W.C.

CORRESPONDENCE.

THE PATH OF VESTA.

To the Editors of "KNOWLEDGE."

SIRS,—Professor Pickering, in an address to the British Astronomical Association, suggested last month that it would be an interesting and useful work for amateurs to trace the path of Vesta in the sky, and to compare its magnitude with those of adjacent stars; so we have made and verified a small map (see Figure 355) with the path of the little planet for alternate days in August, with all adjacent stars down to 7·5 magnitude. The designation of star by number and zone is from the Harvard Durchmusterung, and the magnitude of each is given in Table

XUM

57.[1] "For any amateur who has a good binocular glass, it may prove useful. The magnitude of Vesta on August 4th, according to Dr. Crommelin, is 6·1.

FIAMMETTA WILSON,

S. A. WILSON,

Members of the British Astronomical Association; Membres de la Société Astronomique d'Anvers.

BEXLEY HEATH.

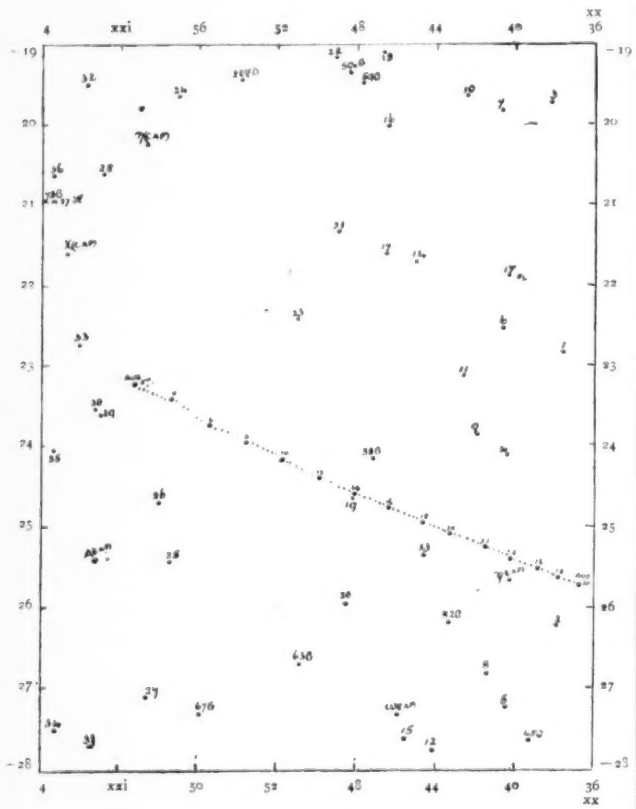

FIGURE 345.

Map of the Path of Vesta showing neighbouring Stars in Capricornis.

Star magnitudes and star numbers from Harvard Durchmusterung.

ABBREVIATIONS.—Fl. = Flamsteed. Number followed by G = number from Manometria Argentina.

TABLE 57.

No. on Map.	Star Number or Star Name in Harvard Durchmusterung.	Mag.	Epoch 1900. R.A.	Epoch 1900. Dec.
			Hr. Min. Sec.	° ′
1	− 22. 5511	7·5	20 37 36	− 22 49
2	− 26. 15227	8·0	20 37 52	− 26 11
3	− 19. 5905	7·3	38 12	19 42
	45 G	6·7	39 12	27 37
	ψ Capricorni Flamsteed	4·3	40 12	25 38
	17 Capricorni	5·9	40 24	21 53
4	− 24. 16262	7·2	40 24	24 6
5	− 27. 15025	7·0	40 30	27 14
6	− 22. 5526	8·0	40 42	22 32
7	− 19. 5921	7·0	40 52	19 48
8	− 26. 15264	7·3	41 24	26 47
9	− 23. 16498	7·5	42 0	23 51
10	− 19. 5928	6·5	42 30	19 38
11	− 23. 16508	7·4	42 36	23 7
	52 G	6·1	43 24	26 9
12	− 27. 15065	7·3	44 6	27 45
13	− 25. 15067	6·9	44 36	25 21
14	− 21. 5844	6·8	45 6	21 40
15	− 27. 15080	6·8	45 36	27 37
	ω Capricorni	4·1	45 52	27 18
16	− 20. 6055	7·0	46 30	20 1
17	− 21. 5852	7·3	46 36	21 36
18	− 19. 5942	8·3	46 42	19 7
	58 G	6·6	47 12	24 9
	59 G	6·5	47 48	19 29
19	− 24. 16339	7·3	48 12	24 39
	59a G	7·3	48 24	19 22
20	− 26. 15326	7·5	48 30	25 57
21	− 21. 5864	7·5	49 0	21 20
22	− 19. 5960	7·0	49 6	19 10
	63 G	6·1	50 52	26 41
23	− 22. 5572	7·5	51 6	22 23
	20 Flamsteed Capricorni	6·2	53 52	19 26
	67 G	6·2	55 52	27 17
24	− 19. 5998	7·0	57 6	19 39
25	− 25. 15195	7·3	57 30	25 28
26	− 24. 16443	7·4	58 0	24 43
27	− 27. 15222	8·1	58 36	27 8
	η Capricorni	5·0	58 42	20 15
28	− 20. 6127	6·8	21 1 0	20 35
29	− 23. 16698	7·4	1 6	23 37
30	− 23. 16700	7·0	1 18	23 33
	A Capricorni	4·8	1 18	25 24
31	− 27. 15255	7·3	1 30	27 41
32	− 19. 6024	7·0	1 48	19 29
33	− 22. 5612	7·8	2 6	22 44
	χ Capricorni	5·3	21 2 48	− 21 36
34	− 27. 15275	7·5	21 3 12	− 27 31
35	− 24. 16495	7·4	3 24	24 2
36	− 20. 6140	7·0	3 30	20 36
	78 G	6·5	21 3 52	− 20 57

REVIEWS.

ARCHAEOLOGY.

Church Bells of England.—By H. B. WALTERS, M.A. F.S.A. 400 pages. 170 illustrations. 9-in. × 6-in. (The Oxford University Press. Price 7/6 net.)

This book taken generally is exceedingly well written, the illustrations, one hundred and seventy in number, are good, especially the one on page 11 showing a man playing on an octave of bells; see also page 31, whereon is shown a finished bell and method of casting. Other illustrations of the "copes," "cores," and moulds joined are interesting (pages 37, 39, 41), and of the completed peal on page 43. The twelve ringers at St. Paul's Cathedral (page 75) forms a good picture, and furnishes an excellent idea of what the ringing chamber there is like. Copies of old prints appear on pages 258, 259, and 260, and these show the "washing," "blessing," and "censing" of a

bell in bygone days, whilst the chapter (XIII) on the decoration of the castings is particularly interesting. It is pleasing to note that the writer agrees with Canon Simpson's principle of tuning bells, and he rightly observes that it is a mistake to retain "maiden" bells in a peal when they would be the better for tuning.

In a complex work of this description there is bound to be a few "slips" which may be well to correct in a future edition. For instance, on page XIII the date of the "Clavis" is given as 1888; it should be 1788. The stating of the changes on page 83 is incorrect, and the same error occurs on page 84. It may be a printer's error on page 83 where the word "*courses*" is given instead of "*changes*," but the writer on page 141 calls "touches" "*peals*." A "peal" is the *extent* of changes obtainable, whilst a "touch" may be a number *less* than the extent.

It is stated that the second bell at Aldbourne, Wilts, was given "by anonymous donors" (page 340), but such is not the case, for the names of the donors are plainly cast upon the bell, and the full inscription is as follows:—

"The gift of Jos: Pizzie and Wm. Gwynn of Aldbourn. . Robert Wells fecit 1787.

Music and ringing we like so well,
And for that reason we gave this bell."

W. L.

CHEMISTRY.

The Interpretation of Radium. Being the Substance of six free popular experimental Lectures delivered at the University of Glasgow.—By FREDERICK SODDY, M.A., F.R.S. 3rd Edition, revised and enlarged. 284 pages. 33 illustrations. 8¼-in.×5⅛-in.

(John Murray. Price 6/- net.)

In the third edition of this work, whilst the original lecture form has been retained, many additions have been made concerning recent investigations, including a new final chapter dealing with the thorium and actinium series of radioactive elements. Controversial matters have been avoided as far as possible, but Mr. Soddy does something less than justice to the electronic theory of matter (with all its faults) when he dismisses it as based upon extravagant assumptions (page 151). Concerning transmutation Mr. Soddy shows that the study of radioactivity indicates the possibility of achieving this; but he asserts that transmutation has not yet been accomplished, entirely ignoring the experimental work of Sir William Ramsay on the subject, which certainly ought to have been mentioned, even if regarded as inconclusive. Another matter that calls for criticism, is that Mr. Soddy does not clearly distinguish between the aim of science (namely, the correlation of phenomena) and that of metaphysics, which is concerned with the source or cause of phenomena. Thus, he uses "matter" as a metaphysical concept, defining "mass" as "quantity of matter" (an exceedingly vague metaphysical expression), whilst at the same time stating that "mass" is measured by "inertia." Energy, moreover, is spoken of in the book as though it were a metaphysical entity.

Apart from these faults, however, it must be freely admitted that there is much that is excellent in the book—as, indeed, one could only expect from a man to whom the science of radioactivity owes so much. Apart from the tendency to untenable metaphysics, already indicated, the style is clear and precise, and the language is simple and adapted to the needs of the ordinary reader, who requires a general account of the new science, in which technicalities and matters of detail are avoided as much as possible.

In one chapter, which is frankly speculative, but by no means the least attractive in the book, there are some very interesting speculations arising out of the consideration of the geological significance of radioactivity and the evolution of the elements. Mr. Soddy suggests that there may have been, in the dim distance of the past, a civilisation on this earth in advance of the present, to whom the secrets of the elements were known, and that the traditional theories of the mediaeval and older alchemical philosophers (which in certain cases, as Mr. Soddy points out, seem to express at times, in allegorical form the views of modern science) were the remnant of heritage from this past.

H. S. REDGROVE.

GEOLOGY.

The Earth: its Genesis and Evolution.—By A. T. SWAINE. 277 pages. 64 illustrations. 8½-in.×5-in.

(C. Griffin & Co. Price 7/6 net.)

Although this work is confessedly a compilation, it may be commended to general readers and lower-grade students as a well-written and, on the whole, trustworthy exposition of the leading factors in the evolutionary history of the earth, with passing notices of the faunas of the different epochs. Scientific terms are avoided so far as possible; but the author in a very large number of instances has given references to authenticate particular statements, so that the student desirous of entering more deeply into the subject will have no difficulty in finding where to turn for further information.

Commencing with the consideration of the various theories of planetary genesis and the beginning of the earth, the author, after a chapter on the leading physical features of the latter and its movements in space, gives an excellent survey of the igneous and sedimentary rocks and their mutual relationship and sequence. Very wisely, he has omitted all reference to guesses as to the supposed age of the globe in years, remarking that these have practically no basis of fact, and also that figures of such magnitude are beyond the scope of the ordinary human understanding. The fact that nearly all the great mountain chains of the old world are of Tertiary age is brought very prominently before the reader; but it might have been added that the stupendous physical changes involved in such movements serve to demonstrate that compensating changes must have occurred in other parts of the world, and consequently that the arguments of those who urge the stability of continents and ocean-basins are of little value. Perhaps the least satisfactory parts of the work are those dealing with extinct vertebrates, with which the author seems to have but a very slight acquaintance. It is, for instance, incorrect to describe the figure of the skeleton of *Diplodocus* (page 168) as that of a restoration of the animal; while the statement (page 171) that the terrestrial dinosaur *Brontosaurus* was not unlike an *Ichthyosaurus* or a *Plesiosaurus* in form will astonish every palaeontologist. It must, too, have been a remarkably big Newfoundland dog that rivalled the ancestral elephant *Moeritherium* (or *Moerithrium*, as it is misspelt on page 196) in size. These, however, are blunders which detract but slightly from the value of an eminently readable book.

R. L.

PHYSICS.

Wireless Telegraphy. — By C. L. FORTESCUE, M.A. 143 pages. 20 illustrations. 6¾-in.×5-in.

(The Cambridge University Press. Price 1/-.)

The series to which this little book belongs has already become widely known, and may fairly claim that it supplies "simple, concise, and reliable information." On such a subject as Wireless Telegraphy this combination of qualities is not easy of attainment. The author has succeeded in putting within the compass of 143 pages the main principles of current induction, condensers, oscillatory currents, resonance, and electromagnetic waves, along with details of the various processes of transmitting and receiving, followed by chapters on wireless telephony and on the history of the development of the whole subject. At a first glance the statements seem to be well and clearly put, and a reader who knows something of electricity in practice will doubtless find much help from a book of this kind. It is doubtful whether any book can supply such help to those who have no practical acquaintance with electricity. These, however, are becoming fewer in number. On page 132 we observe that Hertz is said to have published the results of his experiments with oscil-

XUM

lating currents in the year 1878. Surely two figures have become transposed, for Clerk Maxwell died in 1879. It is, perhaps, unfortunate that three pages are devoted to the Marconi Agreement of 1912.

W. D. E.

ZOÖLOGY.

Text Book of Zoölogy.—By H. G. WELLS, B.Sc. and A. M. DAVIES, D.Sc. 487 pages. 207 figures. 7-in.×5-in.

(The University Tutorial Press. Price 6/6.)

Mr. H. G. Wells, when he was a teacher of Zoölogy, planned out this book, which was rewritten by Dr. Davies. Now the sixth edition has been carefully revised by Mr. J. T. Cunningham, who has added a summary of the modern ideas with regard to evolution, which we have read with very great interest.

W. M. W.

Wild Life in Wales.—By GEORGE BOLAM. 405 pages. 62 illlustrations. 9-in.×6-in.

(Frank Palmer. Price 10/6 net.)

There is a wealth of interesting information in this book which deals first of all with sheep-dogs and agriculture, but as its name implies is mostly occupied with first-hand observations on the wild life of Wales. There are also included some very useful discussions as, for instance, the one with regard to the development of spots on birds' eggs. For the mole it is claimed that the damage he may do is so insignificant that it may be ignored, "while his hillocks form a good top dressing to the grass and are gradually spread by sheep, who thereby, it has been claimed, help to grind off the superfluous growth with their own hoofs." It is pleasant to learn some good also of the carrion crows, which Mr. Bolam says for the greater part of the year are nearly as assidious as rooks in hunting and destroying beetles, wireworms and so on. The lover of nature will be delighted to hear of the chough, the buzzard, the peregrine falcon, the polecat and the marten, and also to see many of the excellent photographs which have been used as illustrations, while here and there those to whom antiquities have a charm will be glad to find details of the hand-plough, the flail and the rushlight.

W. M. W.

"J." A Memoir of John Willis Clark, Registrary of the University of Cambridge and sometime Fellow of Trinity College.—By A. E. SHIPLEY, F.R.S. 362 pages. With 3 portraits. $8\frac{3}{4}$-in.×$5\frac{3}{4}$-in.

(Smith, Elder & Co. Price 10/6 net.)

To almost every Cambridge man who matriculated between the middle sixties and the earlier years of the present century the name of J. W. Clark—abbreviated at first to "J. W." and then to "J"—must have been more or less familiar. For its owner occupied a unique and prominent position at the University, while his many-sided activities brought him into contact with undergraduates of diverse types, from serious zoölogical students to the light-hearted members of the Amateur Dramatic Club. And as every *alumnus* who came in contact with Clark could not fail to be attracted by his genial, if somewhat cynical, disposition, they should all rejoice that the book escaped the dire fate of being privately published.

To the naturalist the chief interest of the book is concentrated in the appendix on Clark's long career (from 1866 till 1891) as Secretary and Superintendent of the University Zoölogical Museum; an institution which may be said to have attained its present high status as a teaching unit as the result of the energy and hard work of its Superintendent, combined, it should be added, with the assistance of the then Professor of Zoölogy, the late Alfred Newton. But Clark succeeded in making the museum under his charge a great deal more than a teaching centre by obtaining for it many collections of high scientific value to which students will constantly resort so long as they remain in existence. Of actual scientific work Clark did comparatively little, partly, no doubt, through lack of the proper training in early years and partly owing to the pressure of his administrative duties. In the early part of his career as Superintendent he published, however, some papers on sea-lions, which were of considerable value in clearing up the confusion then existing with regard to the number of species and their distinctive characters.

No one better suited to the task of writing the life of his old friend could possibly have been found than Dr. Shipley, to whom all contemporary Cambridge men owe a debt of gratitude.

R. L.

NOTICES.

BIO-ECONOMICS.—Dr. Reinheimer is about to issue, through Messrs. Kegan Paul, Trench, Trübner & Company, a contribution to evolutionary science in the form of a volume entitled "Evolution by Co-operation—A Study in Bio-Economics."

FOREIGN BOOKS.—Messrs. W. & G. Foyle have opened at 5, Manette Street, W.C., a Foreign Book Department containing, we are told, volumes in every language and on every conceivable subject, carefully arranged and classified.

SCIENCE FOR ARTISANS.—To meet the want of highly intelligent artisuns for something more concrete than theory, Messrs. Constable & Company are bringing out a series of short, simply-written monographs by competent authorities under the title of "Thresholds of Science." The books will be well illustrated, and the volumes on Zoology, Botany, Chemistry and Mathematics are now ready.

HISTORICAL MEDICAL MUSEUM.—This Museum, which has been set up at 54A, Wigmore Street, is formally recognised as part of the History of Medicine Section of the International Medical Congress which is now being held in this country. The collections are due to the munificence of Mr. Henry S. Wellcome, and to the most interesting specimens and models brought together by his and his assistants' labours we hope to devote a special article in the near future.

SECOND-HAND BOOKS.—Mr. Edward Baker, of Birmingham, has sent us his catalogue of Second-hand Books, numbered 319, and among the thirteen hundred items described in it we notice many having reference to various branches of science, while there are special headings dealing with Botany, Ornithology, and General Zoölogy.

NEW EDITIONS.—Messrs. J. & A. Churchill, of 7, Great Marlborough Street, W., have nearly ready for publication the 7th edition of "The Microtomist's Vade-Mecum," by Mr. Arthur Bolles Lee; the 6th edition of the late Professor J. Campbell Brown's "Practical Chemistry," edited by Dr. Bengough; and the 3rd edition of "A Text-Book of Physics," edited by A. Wilmer Duff.

JOURNAL OF CHEMICAL TECHNOLOGY.—The Publications Committee of the Association of Chemical Technologists announce that in future the "Journal of Chemical Technology," the official organ of the association, will be published quarterly, and that the July number will be the first of the new issue.

BAUSCH & LOMB MICROSCOPES.—We have received the Bausch & Lomb Optical Company's catalogue of microscopes which contains particulars of two new stands "F" and "FF" the latter of which has a focussing sub-stage. A special feature of these microscopes is the base, which is of a modified horse-shoe form of rounded contour. These models, which embody all up-to-date bacteriological requirements have been introduced to meet the popular demand for a high-class instrument at a moderate figure. Incidentally we may mention that the Bausch & Lomb Optical Company have now sold more than eighty-seven thousand of their microscopes.